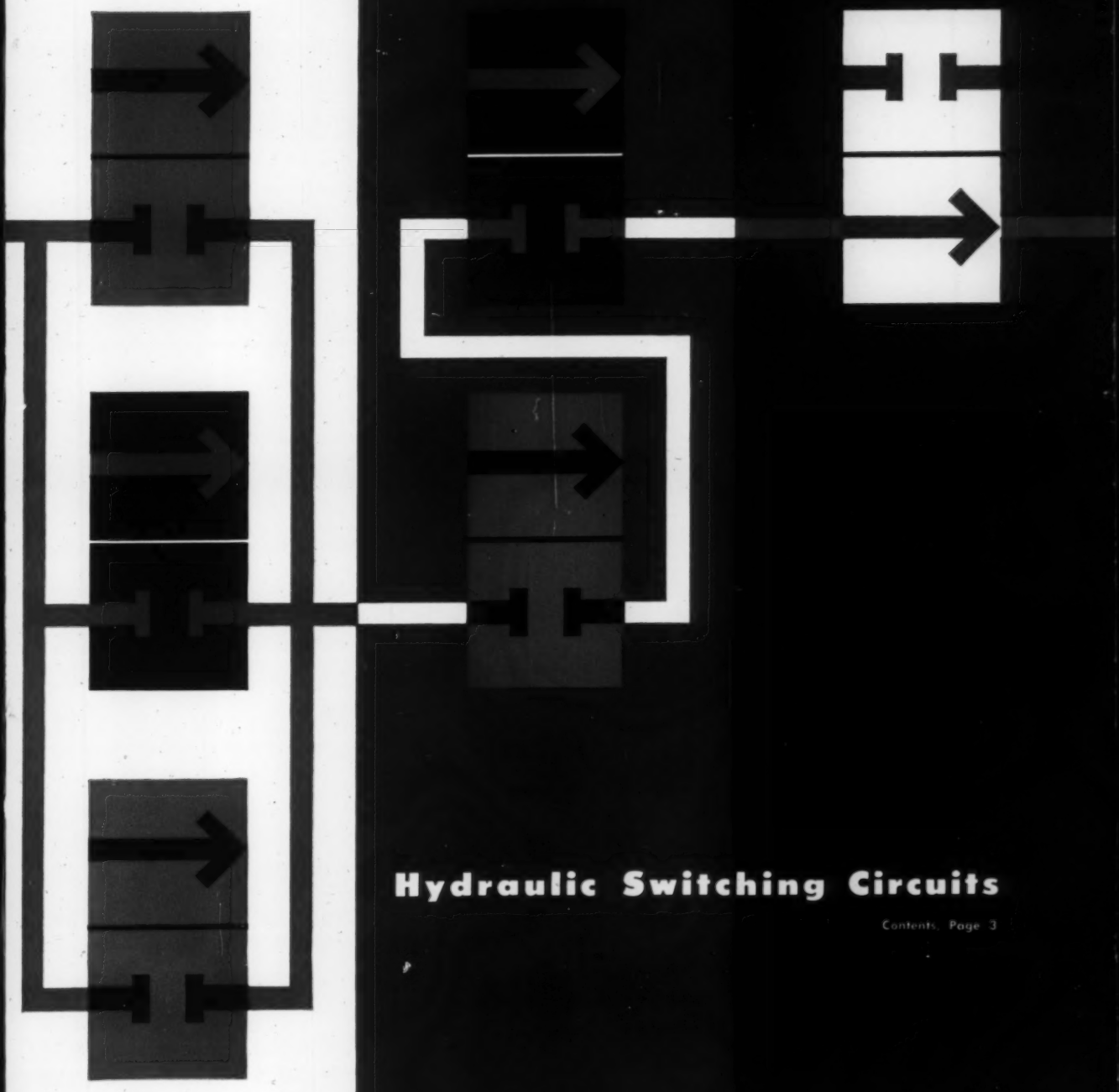
MACHINE DESIGN

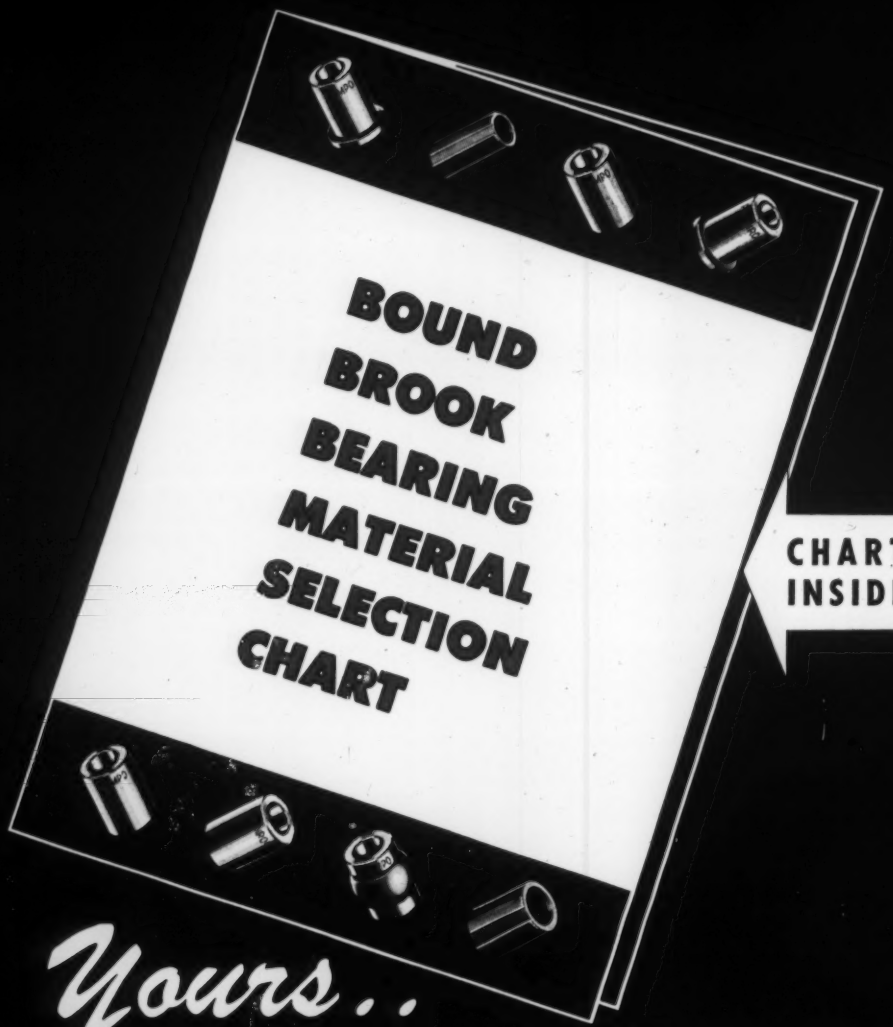
A PENTON PUBLICATION — BIWEEK



Hydraulic Switching Circuits

Contents, Page 3

FARNSWORTH



Yours.. for the asking

The proper material for sintered bronze or iron bearings has always been a major problem to design men. Now for the first time a chart has been engineered, clearly showing the complete chemical, mechanical, and work characteristics of a wide range of sintered bearing materials. The best material for most applications can be selected by a draftsman in a matter of minutes. Only requests on company stationary will be honored.

BOUND BROOK

BOUND BROOK OIL-LESS BEARING CO., EST. 1883, BOUND BROOK, N. J.

Pioneer in

POWDER METALLURGY BEARINGS + PARTS

Combine your motor and speed reducer in one unit
Save space . . . eliminate cumbersome belts, chains, gears
Reduce design and installation time

with BODINE SPEED REDUCER MOTORS

Bodine manufactures the world's most complete line of speed reducer motors in the sub-fractional horsepower range. Speeds down to 0.6 rpm. Torques up to 350 in. lbs. Here's part of the Bodine Speed Reducer Motor line:

. . . single or double reduction reducer for transmitting low torques over a wide range of speeds. The worm is of long wearing nitralloy steel (except for low-powered V-10R and NSP-11R); the gear of laminated bakelite, giving quietness and durability. Motor shaft equipped with ball or sleeve bearings. Speeds from 833 to 1.5 rpm. Torques 12.8 in. oz. to 8 in. lbs.

. . . single reduction, right angle worm gear reducer designed for transmitting moderate torques, Separable hardened and ground steel worm. driven by keyway on end. Laminated bakelite gear on steel hub gives maximum wear and quietness. Speeds from 500 to 29 rpm. Torques 4.5 to 21 in. lbs.

. . . sturdy, single reduction, right angle worm gear reducer, capable of transmitting substantial torques. It has a separable hardened and ground steel worm. Gears of laminated bakelite or hard gear bronze, depending on torque delivered. Grease is used with all bakelite gears; oil with bronze gears. Speeds from 500 to 29 rpm. Torques 11 to 73 in. lbs.

. . . double-worm-gear speed reducer to deliver moderate torques at low speeds. Both primary and secondary worms are of nitralloy steel. Laminated bakelite primary gear assures long wear and quietness; the hard bronze secondary gear carries substantial torque loads. Speeds from 83 to 1.6 rpm. Torques 13 to 52 in. lbs.

. . . double worm gear reducer for transmitting high torques at low speeds. Worms accurately ground from hardened steel; bakelite primary gear assures quietness; hard bronze secondary gear provides long life. Speeds from 24 to 5.7 rpm. Torques 88 to 219 in. lbs.

. . . heavy duty reducer for driving heavy loads continuously with an ample reserve for overloads. Separable steel worms are hardened and ground to size. Gear bronze, selected for strength, is cut by special hobs to close tolerances. Speeds from 173 to 36 rpm. Torques 50 to 198 in. lbs.

Write for technical bulletin 1022B. Twelve pages of facts and figures . . . 33 photos, drawings, curves, and tables tell the complete story of Bodine Worm Gear Speed Reducer Motors. For details of smaller Bodine spur-gear speed reducer motors, ask for bulletin 1023.

BODINE ELECTRIC CO., 2508 W. Bradley Place, Chicago 18

BODINE fractional horsepower MOTORS

BODINE ...the power behind the leading products

How to make motors last longer

Fractional horsepower electric motors, given proper maintenance, will operate without trouble for long periods of time. Here are a few maintenance suggestions:

Check internal switches. While internal switches usually give little trouble, regular attention will make them last even longer. Use fine sandpaper to clean contacts. Be sure sliding member on shaft moves freely. Check for loose screws.

Watch alignment. A motor shaft which is out of line with its load will cause the shaft and bearing to wear rapidly, sometimes damaging the driven machine.

Provide adequate wiring. Be sure that wire of proper size is used to feed electrical power to your motor. If necessary replace wire. It will prevent overheating, reduce your electric power cost, and in many instances prevent future breakdown.

Provide adequate lubrication. Remember, a motor running three times as much as usual will need three times as much attention to lubrication. Provide enough oil, but don't drown your motor. See manufacturer's recommendations.

Watch future Bodine ads for more maintenance tips.

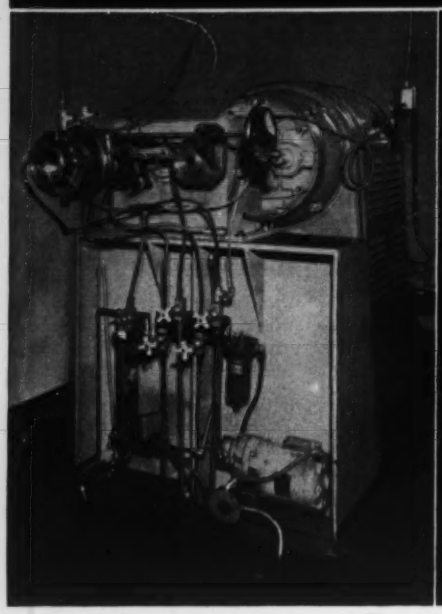
Free chart tells how to locate motor troubles

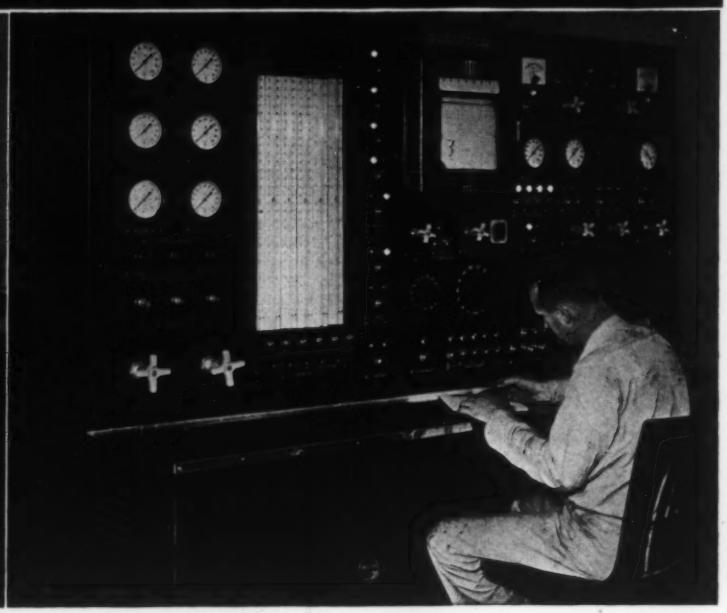
"Common Motor Troubles and Their Causes" is the title of a 1-page bulletin and chart which will help you diagnose ailments of small motors. It lists troubles and probable causes. Copies are available on request.

←Circle 401 on Page 19

Circle 404 on Page 19

Breakthrough





New C/R high-speed laboratories ...testing seals at tomorrow's speeds!

Pushing a design program through on schedule means that there can be no slow-down in any phase. If you know there's a high-speed sealing problem ahead — an accessory drive for a new jet, a hot, fast-rotating shaft in a guided missile, or a bearing in tomorrow's turbine car — plan for it now. Here in Chicago Rawhide's new High-Speed Seal Test Laboratory, C/R engineers now are breaking through present limits, evaluating the design and performance of advanced seal types such as end face, controlled gap, bellows, segmental and bore type seals under such punishing conditions as 80,000 R.P.M., –300° to +1000°F. and 500 psi. C/R is at your service *now* with the most advanced technology and facilities in the country for cooperative research on high-speed sealing problems.

Chicago Rawhide consistently gears itself to the future, ready to meet industry's new problems as they develop today. May we help you?

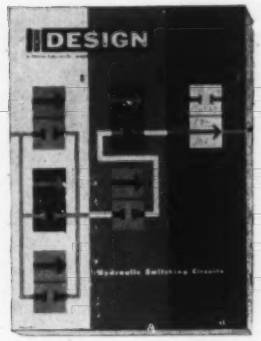
More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

CHICAGO RAWHIDE MANUFACTURING COMPANY
1221 ELSTON AVENUE • CHICAGO 22, ILLINOIS
Offices in 55 principal cities. See your telephone book.
In Canada: Manufactured and Distributed by Chicago Rawhide Mfg. Co. of Canada, Ltd., Brantford, Ontario.
Export Sales: Geon International Corp., Great Neck, New York

C/R PRODUCTS: C/R Shaft and End Face Seals • Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

C/R OIL SEAL DIVISION
CHICAGO RAWHIDE

Circle 405 on Page 19



Front Cover: Logic and mathematics —combined in Boolean algebra—can be a big help in designing certain types of hydraulic circuits. George Farnsworth's cover shows the basic circuits involved, and Harold Ronan's series starting on Page 140 tells how to apply them.

February 19, 1959

What's So Tough About Designing an Army Rifle? . . 22

NEWS REPORT—Meeting the design standards necessary to U.S. principles of sharpshooting is tricky business. Here are the problems involved.

Which Product Model to Build 132

MONTGOMERY FERAR—Practical pointers on the use of full-scale product replicas in design: Why build them, how to select model materials.

Patents of Commercialized Inventions 137

ALBERT WOODRUFF GRAY—Limitations on the commercial use or sale of inventions prior to the filing of an application for a patent.

Hydraulic Switching Circuits 140

HAROLD R. RONAN JR.—*Part 1: AND, OR, and NOT Logic Functions*—Design tools for efficient synthesis of complex hydraulic circuits.

Handles for Electronic Equipment 146

FRANK WILLIAM WOOD JR.—Factors to consider in handle design and use.

Microhoning 153

DON S. CONNOR—When to specify this controlled-abrading process for precision surfaces and close tolerances on high-production parts.

Thermal Stresses 156

S. S. MANSON—*Part 8: Elastic Stresses by Energy Methods*—Complementary energy, single-product method, self-equilibrating polynomials, station functions.

Noncircular Gears 161

FREDERICK W. CUNNINGHAM—How to evaluate and design function-generating gear pairs for greatest effectiveness in specific applications.

Helical-Spring Design 165

J. HIRSCHHORN—*Data Sheet*—Charts and equations for a simple, rapid approach to design of compression and extension springs without trial-and-error calculations.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

February 19, 1959

Volume 31 — No. 4

Lemons and Sour Notes 131

COLIN CARMICHAEL—*Editorial*

Engineering News 6

Printed-circuit armatures cut dc motor weight—ductile ceramics unaffected by heat shock—Air Force reveals nuclear-aircraft plans—hard magnets stay "attractive" in radiation bath—no-skid brake senses vehicle weight—Killian says public confused about engineering—rare metal, rhenium, available for high-temperature applications

Scanning the Field for Ideas 135

Double-wound belt drive—counterbalanced-flywheel system for rotary-to-reciprocating motion conversion—stacked pressure-adding diaphragms.

Design in Action 149

Three engines power three-gang mower—cone spreads falling stream of material into thin layer—plastic biprism combines two image halves into one—hydraulic-mechanical linkage has adjustable-position pivots.

Tips and Techniques

Function values 139
Fastener details 145
Drill depth 145
Cross sections 169

Design Abstracts 171

New Parts and Materials 186

Engineering Department Equipment 242

Professional Viewpoints 246

Engineer's Library 254

Noteworthy Patents 259

Meetings and Expositions 41

Helpful Literature 174

Subject Index 17
Reader Service Cards ... 19
Advertising Index 271
Business Staff 271

IN THE NEXT ISSUE: The future of an engineer . . . deep-hole drilling . . . hydraulic switching circuits . . . how to absorb energy . . . size and location tolerances . . . preferred pinion sizes

Editor
COLIN CARMICHAEL

Associate Managing Editors
BENJAMIN L. HUMMEL
ROBERT L. STEDFELD

Associate Editors
LEO F. SPECTOR
ROBERT C. RODGERS
WILLIAM S. MILLER
SPENCER R. GRIFFITH

Assistant Editors
FRANCIS A. HUSARIK
CLARE E. WISE
JAMES A. PARKS
THEODORE M. LEACH
STANLEY G. COOK
JANE H. SMITH
MARIAN L. EICHAR

Art Editor
FRANK H. BURGESS

Contributing Editor
ROGER W. BOLZ

EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

"I get B&W Mechanical Tubing tailored to the job

As a shop superintendent, I'm sold on B&W. Because B&W Mechanical Tubing comes matched to our needs we've increased production and cut costs."

B&W furnishes a wide selection of mechanical tubing with properties that make it suitable for subsequent fabrication into an infinite variety of hollow cylindrical parts and products. You can usually select a tube with a diameter and wall thickness so close to the dimensions of the final product that machining and finishing costs are subsequently reduced and sometimes virtually eliminated.

B&W Mechanical Tubing not only provides the properties needed in the finished product but also makes possible easy fabrication and a more simplified and improved design. Checking with Mr. Tubes, your B&W specialist, when your product is in the design phase can save you vital production costs.

Write for Bulletin TB-347, The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

B&W TUBULAR PRODUCTS DIVISION

TA-8023-M4

Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals.

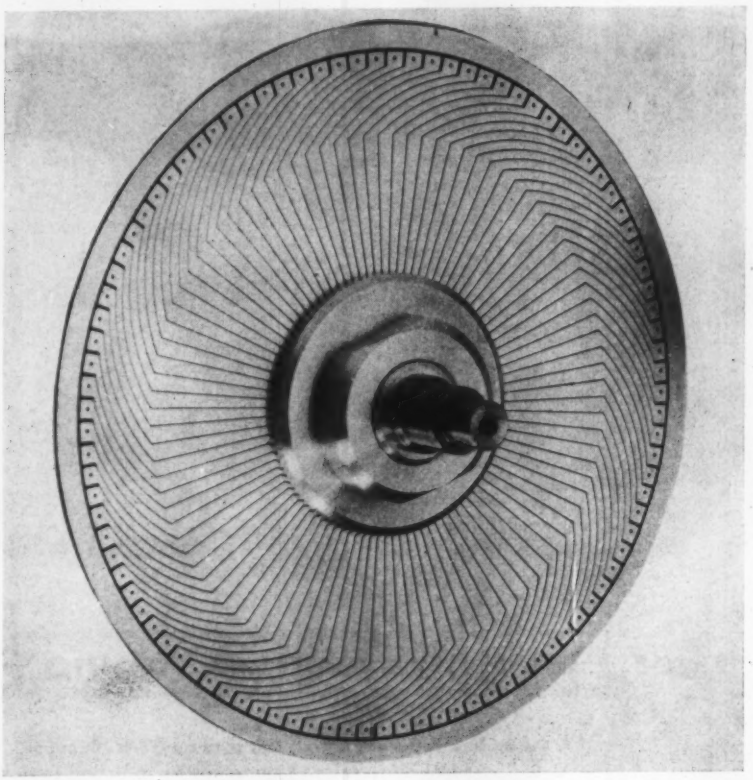
New Motor Family Uses Printed-Circuit Rotors

Disc Armatures Cut Weight, Shorten Time Constants

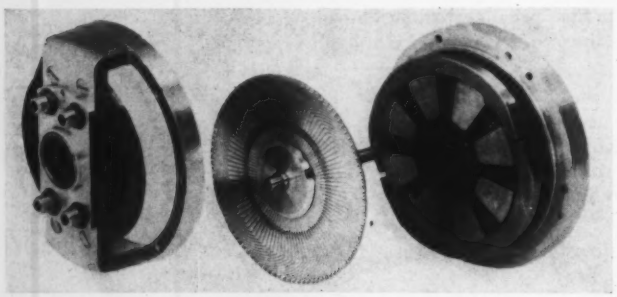
NEW YORK — Printed-circuit armatures, with one-eighth the weight of conventional wire-wound rotors, are the basis of a new concept in direct-current motors. Extremely low inertia of the flat-disc armature suits the printed-circuit machine to a wide field of application in servomechanisms, paper and magnetic-tape transports, intermittent-motion devices, and data-processing equipment.

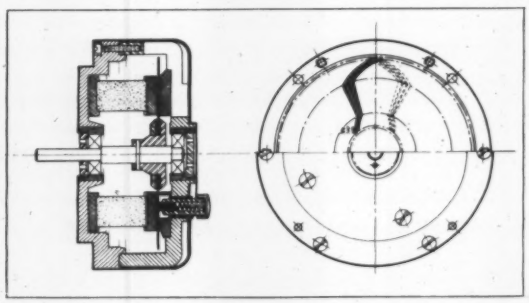
Because the armature can be mass-produced by conventional printed-circuit techniques without hand soldering, cost of the new motor is expected to be under that of comparably rated standard machines. Other advantages foreseen are:

- Low armature reactance: The rotating portion of the machine contains no iron; inductance of the ribbon windings is less than 1 mh.
- Low time constant: The lightweight armature permits time constants on the order of a few millisec. In tests where 60 cycle ac was applied to the motor, it reached full speed in opposite directions on each half cycle.
- Smooth commutation: Silver-graphite brushes ride directly on the

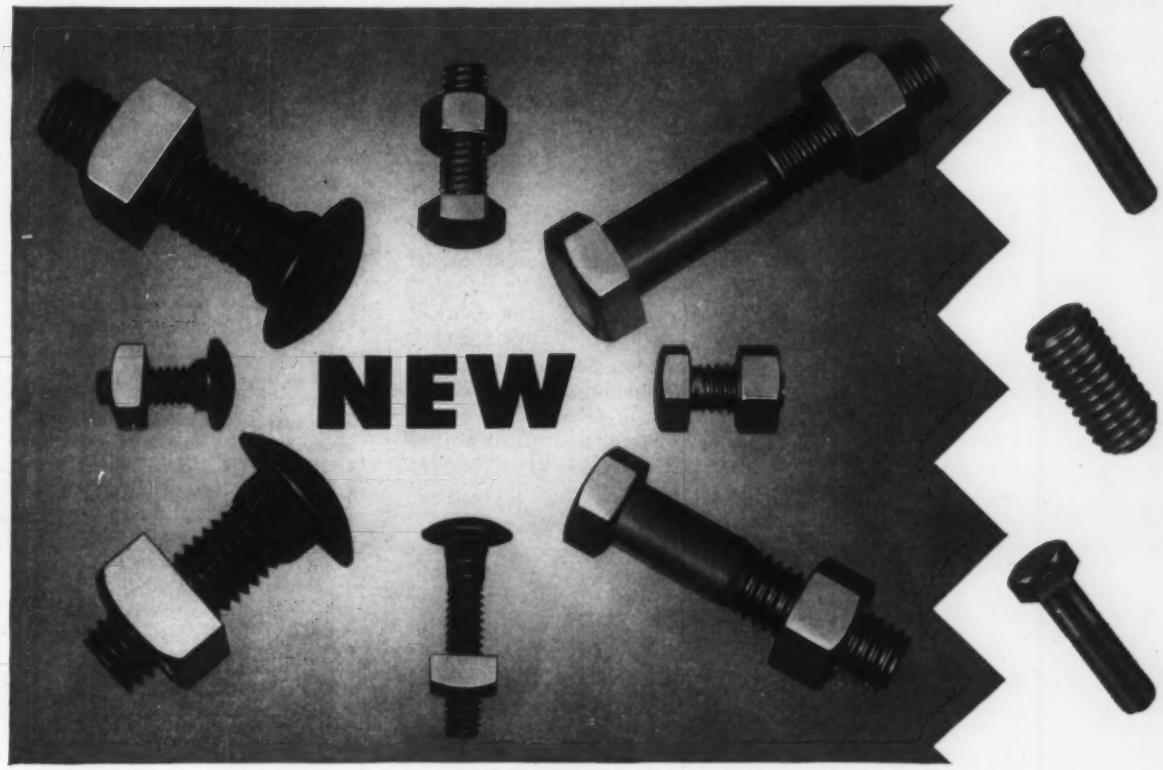


Ribbon-like copper conductors—printed on both sides of the epoxy-glass disc—are connected by plated-through holes. Separate commutator is not required for most printed machines; silver-graphite brushes ride directly on the conductors. Since the windings can be arranged to avoid simultaneous commutation, and since the disc contains no iron, torque output is smooth and armature reactance is extremely low. Time constants are measured in milliseconds.





Flat-disc armature in the printed-circuit dc motor mounts in a planary air gap (right). Straight radial conductors lie within the flux of the permanent-magnet field poles (left). The printed-conductor group forms the equivalent of multi-polar wave windings in conventional machines. Large surface area of the conductors allows use of current densities up to 30 to 40 amp per sq mm. Eddy-current damping can be obtained through use of conducting armature discs.



Machine Bolts and Carriage Bolts Now Produced to Stanscrew Quality Standards

Stanscrew presents a new line . . . carriage and hex machine bolts . . . now produced and stocked in a complete selection of more than 500 different sizes. Manufactured under careful quality control methods, they meet the same standards of uniformity and dependability which have made other Stanscrew fasteners a leading choice of American industry for over 80 years.

These new additions bring Stanscrew's complete line to over 5,000 different types and sizes of standard, catalogued fasteners. From this comprehensive selection you can find dependable, economical answers to the overwhelming majority of all your fastener needs.

Your Stanscrew fastener specialist, available through your nearby Stanscrew distributor, can show you many ways these inexpensive standard items will cut your product costs . . . for example, by replacing costly special fasteners.

Each of the over 5,000 different Stanscrew fasteners is always kept in stock at three conveniently located plants. This enables your Stanscrew distributor to provide faster service . . . to be particularly helpful in emergency situations where prompt delivery can mean substantial savings.

So, whatever your fastener requirements, just call your nearby Stanscrew distributor. Or for complete information on Stanscrew's new carriage and machine bolts, simply mail the coupon below.

STANSCREW FASTENERS

STANDARD SCREW COMPANY

CHICAGO | THE CHICAGO SCREW COMPANY, BELLWOOD, ILLINOIS

HMS | HARTFORD MACHINE SCREW COMPANY, HARTFORD, CONNECTICUT

WESTERN | THE WESTERN AUTOMATIC MACHINE SCREW COMPANY, ELYRIA, OHIO

Standard Screw Company
2701 Washington Blvd.
Bellwood, Illinois

Please forward complete information on

☐ Machine bolts ☐ Carriage bolts

Name_____ Title_____

Company_____

Address_____

City_____ State_____

Circle 407 on Page 19

bare armature conductors, giving a large number of active segments. Torque is completely free of cogging at any speed.

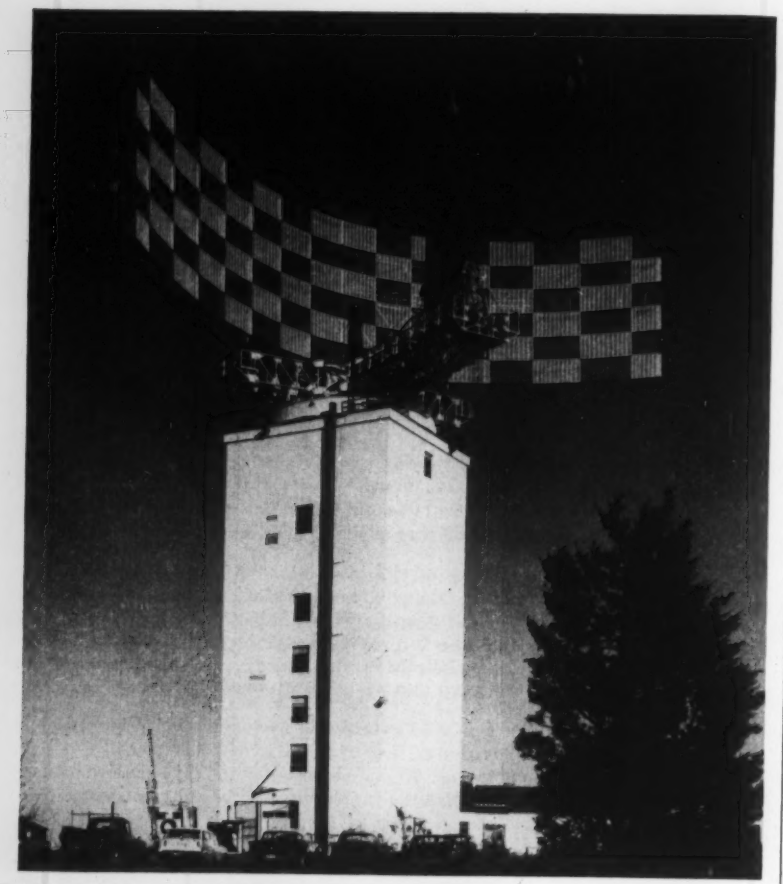
• High - temperature operation: All active armature conductors are uninsulated, and the glass-fiber disc is virtually unaffected by heat. Flat form of the machine leads to effective cooling.

• Wide power range: Shaft output power of the printed-circuit machines ranges from a few watts to several kilowatts.

• High torque at low speed: This characteristic eliminates need for a gear train to smooth motor torque in servomechanism applications.

Operating principles of the printed motor are generally the same as for more conventional machines. However, the U. S. manufacturer of the printed armature—Photocircuits Corp.—points out that, because of their special characteristics, printed-circuit machines should generally not be considered as direct substitutes for conventional motors. Where necessary, special forms of the machine, combining windings and slip rings for ac and dc operation, can be tailored to fit special requirements.

Inventors of the printed-circuit motors are F. H. Raymond and J. Henry Baudot, Societe d'Electronique et d'Automatisme, Paris. Photocircuits Corp., Glen Cove, N. Y., has developed the advanced printed circuit and base fabricating techniques required for the motor parts.



Giant Radar Stands Watch on Boston Hill

Thrusting its inquisitive radar nose hundreds of miles into territory surrounding North Andover, Mass., this Army-Navy-Air Force sponsored experimental station uses a ten-foot klystron as transmitter power tube. The 120-ft wide, 50-ton antenna rotates on 13½-ft-diam ball bearing at speeds up to 5 rpm and maintains directional accuracy within 0.1 degree. MIT's Lincoln Laboratory will use the station, under supervision of the Air Research and Development Command of the Air Force, to test components and circuitry for future high-power radar.

Topics

Nonstatic suggestion box rises and shines to call attention to itself. In use at the U. S. Bureau of Reclamation, Sacramento, Calif., the "Genie" has an electric eye that lets it know when someone is approaching; then a music box plays, a printed tape gives a suggestion pep talk, and a device at the bottom of the box administers a shoe shine.

• • •

AC anesthetic for operations is provided by a device recently patented by a Japanese inventor. Plugged into an ordinary circuit, the device has a transformer which converts current from alternating to direct. A dentist's drill, a probe, knife, or needle serves as the positive terminal; a negative terminal is attached to the patient's skin. A foot-operated rheostat regulates current so that it deadens pain but does not cause it.

• • •

Scotch tape goes picnicking on the bottoms of paper plates, where it serves to prevent sliding, spilling, or blowing away. Bottoms of Sta-Put plates, developed by Superior Paper Products Co., Marion, Ind., and Minnesota Mining & Mfg. Co., St. Paul, have tabs of double-coated tape to anchor the plates to any surface. Plates pull away easily and do not mar surfaces.

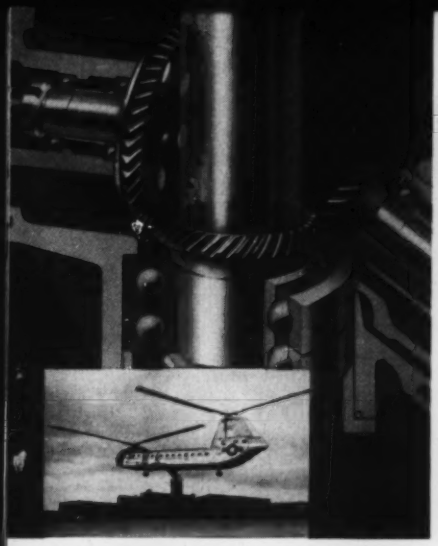
• • •

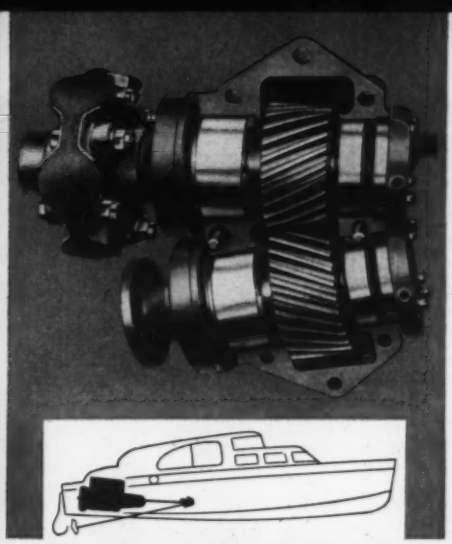
Little green men may be heard but not seen when first contact is made with inhabitants of other planets. This is the theory of Maj. Gen. Donald J. Kiern (USAF), who, in a speech before the IAS, advanced his belief that communication with such beings, if they exist, will take place before face-to-face meeting. To facilitate contact, Gen. Kiern favors establishing a moon or space station to intercept signals. Otherwise, he feels, the signals may be so weakened by the time they reach the earth they would be lost in our noisy atmosphere.

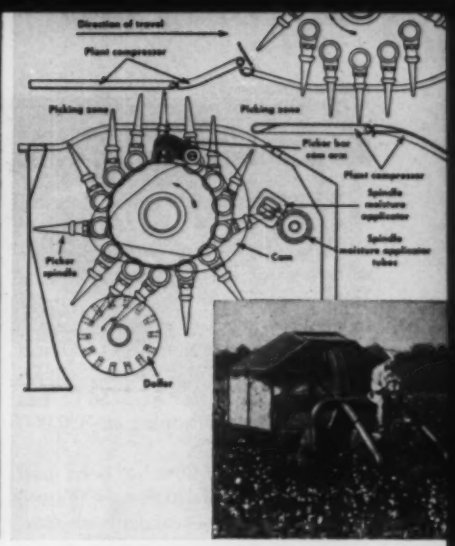
• • •

In honor of engineers and their work, next week has been proclaimed

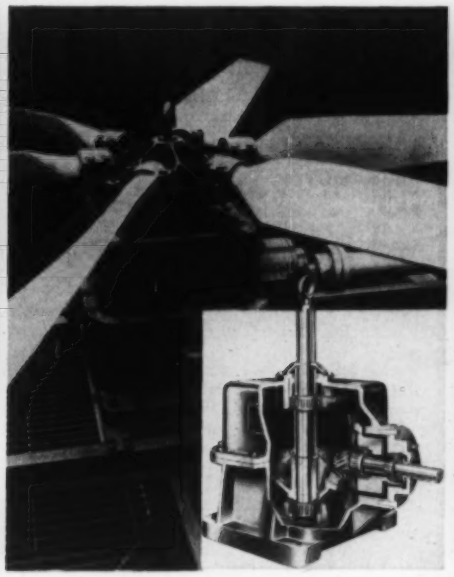
National Engineers' Week. Observance is sponsored by the National Society of Professional Engineers.

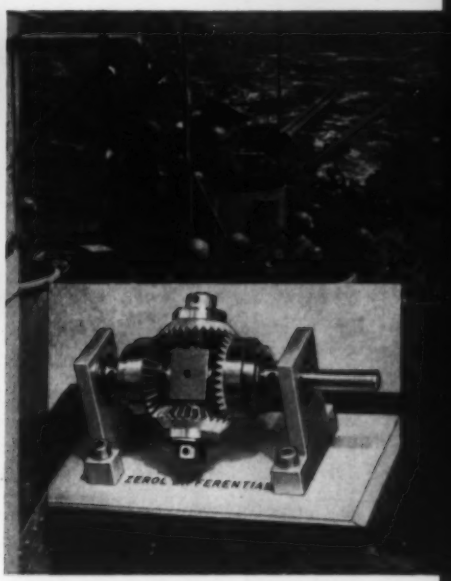






CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.
BEVEL GEARS





What happens when you use right angle or angular drives?

More flexibility. Instead of designing *around* your transmission, you can design a transmission *into* your products with angular drives.

The *helicopter*, for example, is made more compact by having a single drive source service both a blower and a pump. The drive on the *speedboat* gives better balance and more usable cabin space. The *cotton picker* runs fourteen separate picking spindles off one drive member.

Greater accuracy. Using Gleason machines and methods you can grind or cut bevel gears to exceptionally close tolerances. The complete accuracy and reliability needed in the *missile* and *fire control unit* are obvious.

Heavier loads. An angular drive can stay compact and still carry heavy loads such as the one on the gear reducer in the *cooling tower fan*.

Full engineering help. A large and competent staff of Gleason engineers is yours to call on for help in early design work, for the manufacture and testing of prototypes, for selecting and setting up of machines and methods, and for any other assistance you might need.

Free literature. To become better acquainted with the advantages and the theory of bevel gear drives, send for these Gleason Manuals:

20° Straight Bevel Gear System
Spiral Bevel Gear System
Zerol® Bevel Gear System

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

Circle 408 on Page 19

Rare Metal Rhenium Being Produced Commercially

Wide Usage Predicted in Metallurgy and Electronics

WATERBURY, CONN.—First commercial production of rhenium in the U. S.—by Chase Brass & Copper Co.—gives designers a new high-strength, high-temperature material to work with. The dense, silver-colored metal melts at 5756 F; has tensile strengths ranging to 350,000 psi.

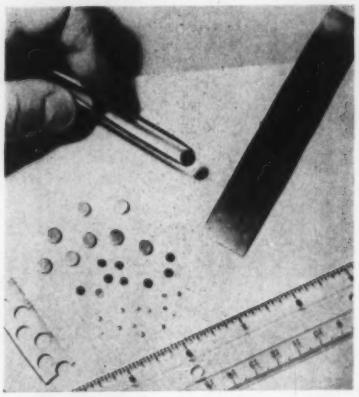
Until now, rhenium has been used in a variety of high-temperature control and measurement applications. Thermocouples made of rhenium and tungsten, for example, withstand temperatures of 4500 F.

Surefire commercial applications will include electrical and electronic components. Chase says electrical relay contacts made of rhenium combine the best electrical and mechanical properties of all other contact materials now in use. Such contacts resist wear, corrosion, and pitting.

Rhenium is also well suited for making filaments and structural components for vacuum tubes. Its ductility at room temperature permits easy forming and shaping; it has strength at high temperature, good weldability, and high purity.

While rhenium is not a structural metal, it shows definite promise as a welding material for molybdenum. Recent research has also shown that rhenium-molybdenum alloys have better mechanical properties than molybdenum, at a lower cost than pure rhenium.

Chase produces the metal in wrought rod, wire, and strip. Rod and wire ranges from 0.175 to 0.003 in. in diam; strip from 0.175 to 0.002 in. thick. U. S. production capacity is about 30,000 lb per yr.



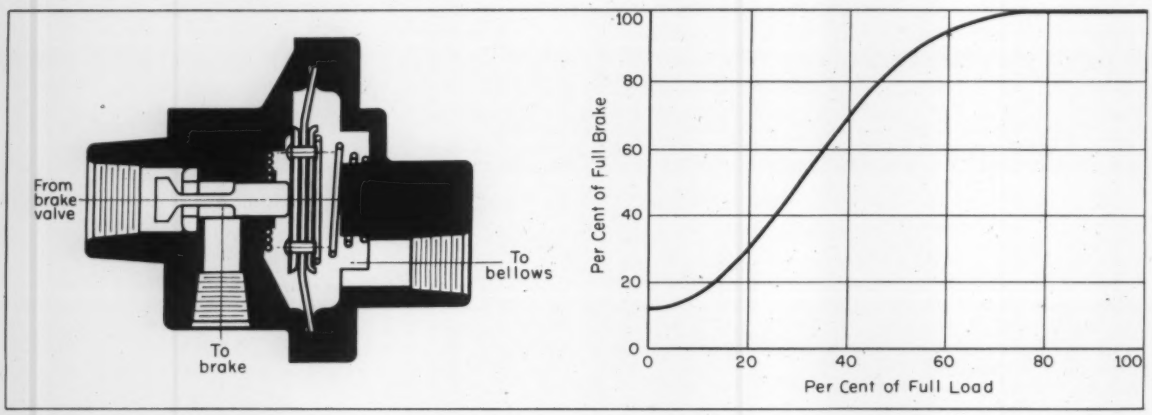
Rhenium electrical contact discs, blanked from a strip of the rare metal, have shown a life expectancy 20 times greater than relay contacts made of the best conventional materials.

Rhenium: Mechanical Properties

	Tensile Strength (1000 psi)	Elongation (% in 2 in.)	Hardness (Vickers)
0.050-in. strip, annealed	165	10	270
As rolled (20% reduction)	285	2	525
0.150-in. rod, annealed	170	13	285
As swaged (10% reduction)	...	..	600
0.030-in. wire, annealed	165	15	250
As swaged (10% reduction)	287	2	500

General Properties

Density	21 gr/cc
Melting point	3180±10 C
Modulus of elasticity	67×10^6 psi
Electrical resistivity	19 microhm/cm
Thermal expansion	67×10^{-6} from 20 to 500 C
Oxidation resistance	Good to 600 C
Corrosion resistance	Resistant to halogen acids, attacked by oxidizing acids.



Fast Stop for Trucks

Braking stability under all load conditions is assured with a new brake-regulating valve developed by GMC Truck and Coach Div. Used only on tractors with air suspension (GM recently introduced two new models), the valve automatically adjusts braking effort at the rear wheels. Pressure within the air-suspension bellows, which varies in exact proportion to the load on the wheels, controls the valve setting. Trailer brakes remain independently controlled. Before GM developed its modulated truck brake, fixed division of braking effort between front and rear wheels provided optimum braking only under one load condition (usually full load). When tractors traveled empty, the change in weight distribution between front and rear axles resulted in about one-sixth the normal deceleration because rear wheels would slide. Now, truck stopping distance is reduced to near that of a car.

ARISTOLOY

COLD FINISHED BARS

COLD DRAWN BARS
Rounds . . . 1/2" to 3-1/4"
Hexagons . . . 9/16" to 1-11/16"

TURNED BARS
11/16" to 6-1/4" incl.

TURNED AND POLISHED BARS
11/16" to 3-1/2" round

GROUND AND POLISHED BARS
1/2" to 3" rounds

TURNED, GROUND AND POLISHED BARS
11/16" to 4" rounds

BEARING QUALITY • AIRCRAFT • PISTON PIN QUALITY • ELECTRIC FURNACE ALLOY ELECTRIC FURNACE CARBON • ALLOY BASE ALLOY • QUALITY CARBON

LEADED* — Electric Furnace 52100 Electric Furnace Alloy • Electric Furnace Carbon • Alloy Base Alloy • Quality Carbon

STAINLESS—300 Series • 400 Series • 500 Series
*Inland Ledloy License

NEW PRODUCTS & FACILITIES CATALOG

Describes melting, rolling, thermal treating and finishing capacity of Copperweld's Aristoloy Steel Division. Complete product listing for Aristoloy carbon, alloy, stainless, leaded and nitriding steels. Send for your copy today.

ARISTOLOY STEELS

COPPERWELD STEEL COMPANY

ARISTOLOY STEEL DIVISION • 4017 Mahoning Ave., Warren, Ohio • EXPORT: Copperweld Steel International Co., 225 Broadway, New York 7, N. Y.

Circle 409 on Page 19

Nuclear-Aircraft Plans Detailed by Air Force

First Manned Plane Will be Subsonic Testbed-Weapon

NEW YORK—Confusion and controversy in Washington concerning the flight of a nuclear airplane tend to obscure the fact that AEC is directing well-established research programs on more than one type of nuclear powerplant. And while no atom-powered vehicle is in the air yet, major problems in getting one off the ground are being worked out on a steady, subcrash basis.

At the recent IAS meeting in New York, Maj. Gen. Donald J. Kiern, USAF Deputy Chief of Staff for Development of Nuclear Systems, described four nuclear-powerplant research programs currently well under way:

Manned Aircraft:

Recent progress in aircraft design, plus integrated shielding techniques, have effectively reduced overall weight of the projected nuclear aircraft. Potential radiation damage to air frames and radiation dose rates to crews have also been cut drastically. With designs now on the board, each crew could fly 1000 hr per year on nuclear power, including missions of well over 100-hr duration.

A modified B-36, carrying a 1 megawatt reactor and shielded crew compartment, has logged 47 flights to date. This airborne research, supplemented by years of research on the ground, has cleared up most of the critical problems in the manned-aircraft project, according to General Kiern. He said the next logical step is developmental flight testing of a militarily useful aircraft.

Project Pluto:

The nuclear ramjet, as a missile powerplant, is particularly attractive to the Air Force. It would give a missile the highest payload to gross-weight ratio of any intercontinental strategic weapon and would thus be cheaper than any other system. Traveling at supersonic speeds for extreme ranges, at low level, the aerodynamic missile could freely maneuver and change direction. Monitored inertial-guidance techniques would give it deadly accuracy.

Immediate objective is a feasibility demonstration of the reactor at temperature and power densities suitable for ramjet propulsion. Prime responsibility rests with E. O. Lawrence Laboratory, formerly University of California Radiation Laboratory.

Project Rover:

In an even higher temperature regime than turbojets or ramjets is the nuclear rocket. Gen. Kiern described development of the rocket as a long-range effort which will eventually provide the capability for full-scale space travel.

By using low molecular weight propellants such as hydrogen, the heat-exchanger type system currently under development provides specific impulses two to three times greater than those obtainable from the most advanced chemical propellants. With increasing payload, there is a point at which this system surpasses chemical systems in efficiency.

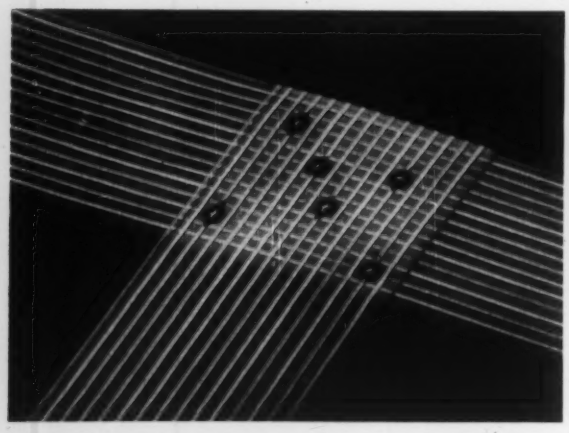
The nuclear-rocket engine can be utilized as a primary booster, or as a stage with conventional rocket engines. Sophisticated methods of utilizing energy available from the fission process are currently being studied by Los Alamos Scientific Laboratory, under AEC contract.

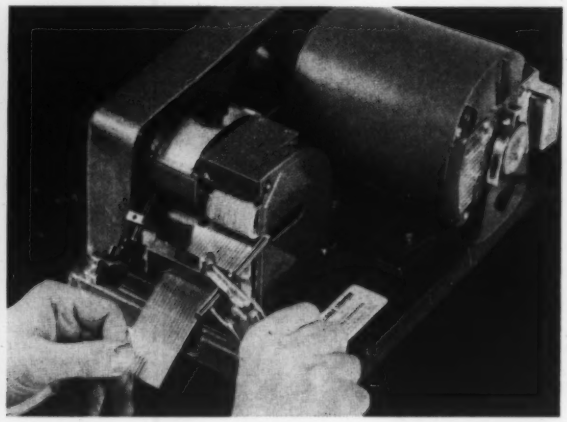
Snap:

In addition to basic weapon systems, the Air Force places high priority on the development of nuclear auxiliary-power devices. These are needed as a source of electrical power for satellites and space vehicles. While present satellites use several watts of power, it will require kilowatts to televise live from a lunar orbit, or to communicate between Mars or Venus and the Earth.

Both radioisotope and nuclear-reactor energy sources are being researched by AEC. Direct conversion, which depends upon the thermoelectric effect of materials, and conventional thermodynamic cycle conversion are two methods being utilized to transform nuclear energy into useful electrical energy.

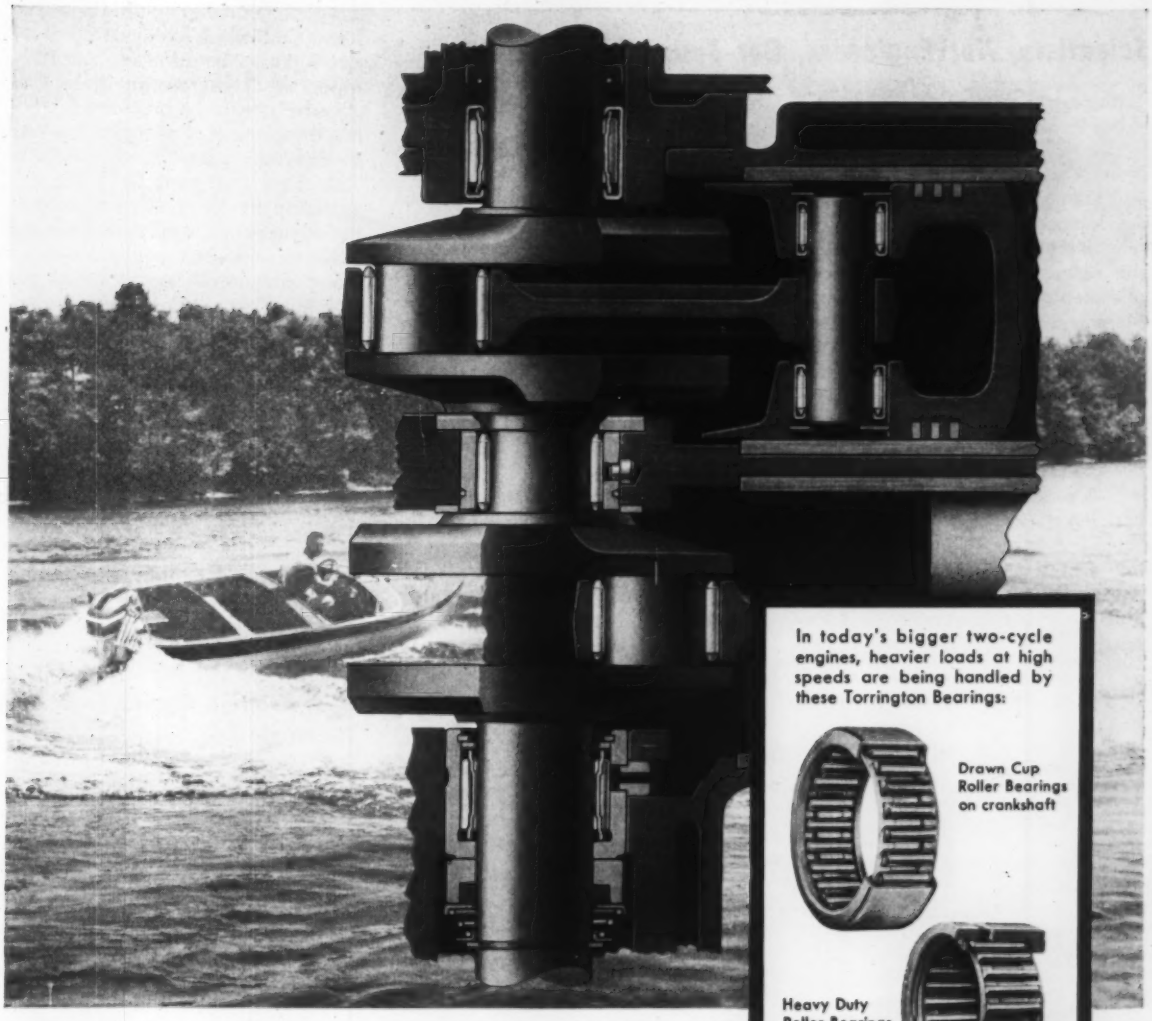
Significant progress is being made on both the energy sources and the conversion techniques. A small radioisotope-powered, direct-conversion device is already operational. Fueled with polonium 210, the unit weighs aproximately 5 lb and produces 5 w of useful electrical energy at efficiencies of about 8 per cent.





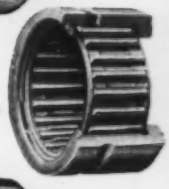
New Techniques with Flat Cable Speed Assembly

Techniques for harness fabrication with flat cable that actually cut assembly time on an organ console from 22 hr to 30 min were revealed recently by Tape Cable Corp., Rochester, N. Y. Among techniques presented were: Tape can be spliced by overlapping about an inch of material and spot-soldering conductors in an alternating, double-row pattern. Time can be saved on repeated soldering of intersections by soldering through holes in a template. Lines can be interrupted by punching through conductors using holes in a template. A special machine (right) strips plastic from conductor ends to permit splicing or fastening to printed circuits by dip soldering.

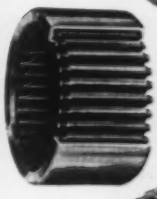


In today's bigger two-cycle engines, heavier loads at high speeds are being handled by these Torrington Bearings:

Drawn Cup Roller Bearings on crankshaft



Heavy Duty Roller Bearings



Full Complement Needle Bearings on wrist pins

Needle Rollers with crankpin ends

Fractured outer race for center main on crankshaft

What's new in two-cycle engines?

Today's improved performance and increased power made possible by recent developments in Torrington Bearings!

In this schematic drawing of a typical two-cycle engine, a Torrington Drawn Cup Roller Bearing and a special Torrington Heavy Duty Roller Bearing provide several improvements in the crankshaft mounting. Shaft-riding retainers guide the rollers at the pitch line and provide ample lubricant circulation. Positive roller guidance insures correct bearing performance despite shaft deflection. Split center bearing on crankshaft features a fractured outer race for positive location of the race halves.

Full complement Torrington Needle Bearings and Needle Roller assemblies with crankpin ends complete the compact, high-capacity design to insure long, trouble-free service life. To secure the advantages of modern Needle Bearing design in your application, consult Torrington's engineering department. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

TORRINGTON BEARINGS

District Offices and Distributors in Principal Cities of United States and Canada

NEEDLE • TAPERED ROLLER • SPHERICAL ROLLER • CYLINDRICAL ROLLER • BALL • NEEDLE ROLLERS • THRUST

Circle 410 on Page 19

Scientists, Not Engineers, Get Space-Age Credit

Engineering Needs Definition For Public Understanding

NEW YORK—Building of satellites and atomic submarines—in fact, the development of nuclear power itself—have been chalked up as scientific rather than engineering accomplishments by the general citizenry. Main reason for such lack of credit where credit is due stems from uncertainty as to just what the engineer's role is. Such confusion disturbs scientists as well as engineers.

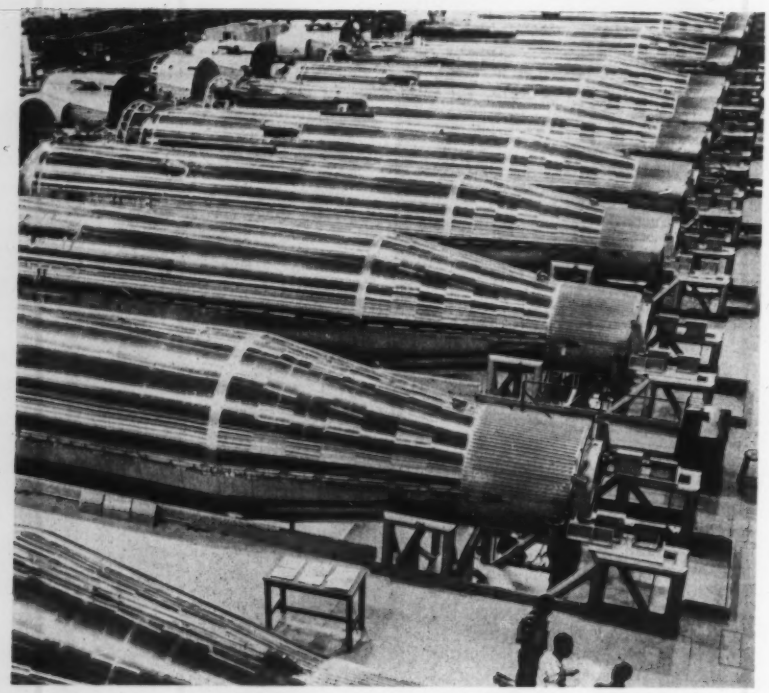
It is up to members of the engineering profession to publicize itself, according to Dr. James R. Killian Jr., chairman of the President's Science Advisory Committee. Speaking at the annual meeting of the American Institute of Electrical Engineers, Dr. Killian said that "we need to bring more clearly into focus the image of the engineer in the minds of our citizens."

He cited last fall's significant drop in enrollment in engineering schools as a result of "the great stress on science" and lack of public knowledge of what the engineer does. Dr. Killian said, "I do not advocate any less emphasis on science and its importance. I do urge a comparable emphasis on the role and importance of the engineer.

"I submit that the great engineering societies have a responsibility and opportunity to deal aggressively with this problem. It is important to the future strength of the engineering profession that they do so."

Another problem mentioned by Dr. Killian is that of making the engineering point of view a part of national policy-making. Efforts in this direction made by the Engineers Joint Council and engineering societies must, he believes, "be fully supported if engineering is to deal effectively with the problems involving the place of the engineer in our society . . ."

A third need seen for U. S. engineering by Dr. Killian is a "major advance" in education. He accuses undergraduate preparation of being not significantly above the training of technicians and urges expanded graduate study. Strengthening of graduate study will in turn enrich the undergraduate program. Pointing to industrial training programs as an indication of the need for further education, he said, "If we had the graduate school capacity to handle these men, it would be more appropriate and advantageous for them to receive their advanced training in the university, rather than in industry."



Production-Line ICBM Will Arm Western Squadron

Atlas missiles coming from this San Diego assembly line are scheduled for operational use at Vandenberg Air Force Base, Calif. First production-line picture of the 75-ft, stainless-steel missiles shows booster sections pulled back (upper left) to permit simultaneous installation of two booster engines and the sustainer engine. Test missiles are delivered from Convair Div. of General Dynamics Corp. to Sycamore Canyon and Edwards Air Force Base for static test and to Cape Canaveral for use on the Atlantic Missile Range.

U. S. Aviation Agency Tests Electronic Taxi Strip Control

Ground-Control System Solves Runway Traffic Jams

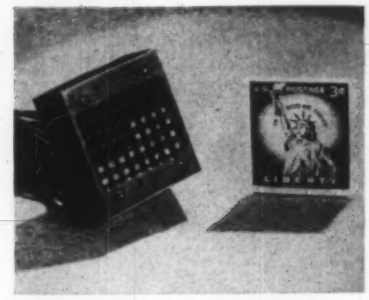
ATLANTIC CITY, N. J.—An RCA-developed vehicle detector is the heart of a runway traffic control system being installed this year at the National Aviation Facilities Experimental Center under the direction of the recently created Federal Aviation Agency (FAA). The FAA hopes to develop a system that would electronically control an airliner from the moment its wheels touch the runway until passengers are deplaning at the ramp.

In the prototype system, a series of wire loops and detector units is buried in the ground at close intervals along runways and taxiing strips. Planes or vehicles passing over the units generate electric currents which flash position-warning lights in the control tower.

RCA spokesmen point to an experimental stretch of highway in Lincoln, Nebraska, where the same type of loops and detectors were used to steer and brake automobiles in response to signals from slow-moving vehicles ahead. They are confident that the system can be used for aircraft taxi control.

A final step would be complete

computer control of incoming planes. The computer could schedule landing and taxiing route for each plane; it could predict and avoid possible collision courses, leaving controllers free to make other important decisions, says RCA. Not only will the system keep track of planes on the ground, it will spot service equipment and unauthorized vehicles on the runways to avoid dangerous and costly accidents.



Tiny Lamps Put Bits on Film

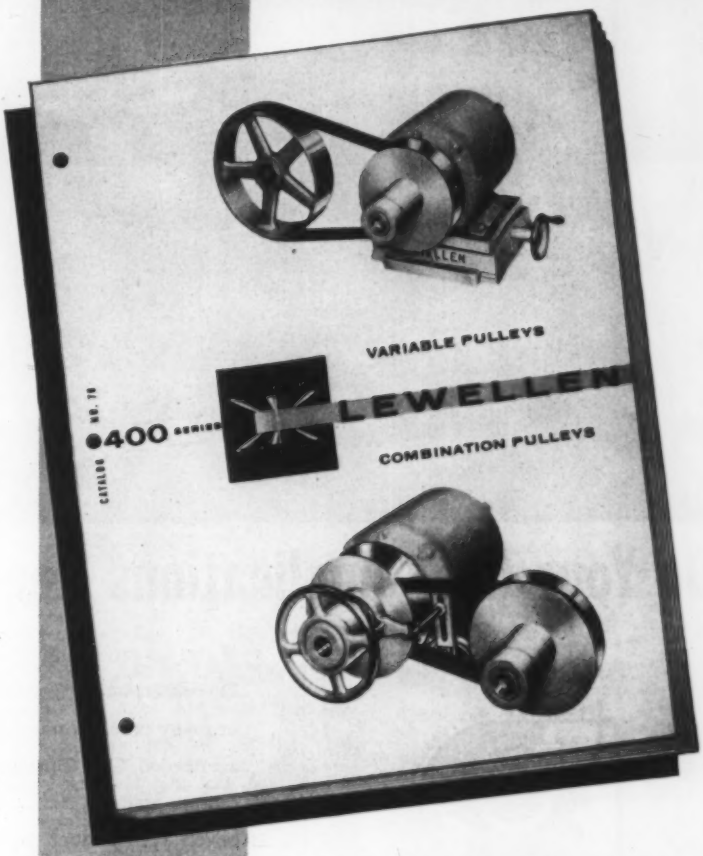
Pinhead-size lamps in batteries of 48 form tiny matrices which print digital information on movie film. A single frame of film will show two of the tiny batteries of lamps, called Digital Recorders by the developers, Magnavox Corp., making a 96-bit matrix. Image of a single lamp is 10 mil square and is separated from its neighbors by 10-mil spacing. Recorders are offered on a 35-mm movie camera by the Traid Corp., Encino, Calif. At its top speed of 80 frames per sec, the camera records 7680 bits.

Fire-Finished Glass Competes with Plate

Distortion-Free Product Floats on Molten Metal

ST. HELENS, ENGLAND—Sheet glass comparable in quality with plate glass comes right from the furnaces of Pilkington Brothers Ltd., England. Secret of distortion-free glass is the gradual cooling; a continuous ribbon of glass coming from the furnace floats across a pool of molten metal. The glass needs no further treatment. Predicted uses include car windshields, store windows, and mirrors. Present limited quantities are sold at plate-glass prices; but quantity production will lower the price considerably.

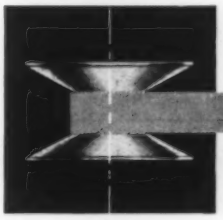
NEW 400 SERIES
LEWELLEN
VARIABLE-SPEED PULLEYS



higher ratings
•
wider speed ranges
•
less space
•
lower prices

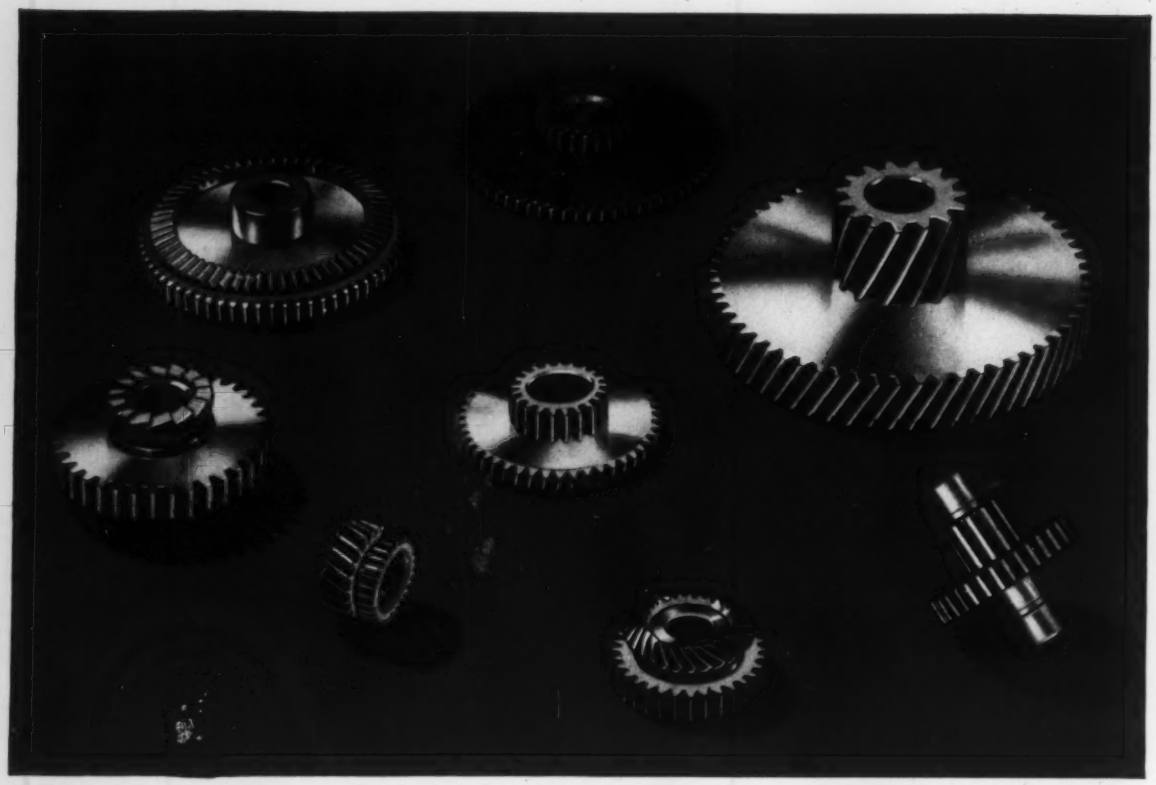
HERE are design changes that greatly enhance the flexibility, usefulness and convenience of Variable-Pulley Drives. Directly connect motor and machine. Get infinitely variable speeds, compactly and economically. Adjust speeds accurately and conveniently while running. Variable-Speed Pulley — Ratings to 15 H.P.; Speed Ranges to 4:1. Variable-Speed Combination Pulleys — Ratings to 25 H.P.; Speed Ranges to 10:1.

REQUEST A COPY OF OUR NEW CATALOG No. 70,
(illustrated above)



LEWELLEN
Manufacturing Company, Columbus, Indiana
Distributors in All Industrial Areas. In Canada — Peerless Engineering Sales, Ltd., Toronto-Montreal

Circle 411 on Page 19



Do Your Gear Applications Require CLUSTERS?

FRACTIONAL HORSEPOWER GEARING

GEAR
Specialties, Inc.
2635 WEST MEDILL AVENUE
CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS
OF FRACTIONAL HORSEPOWER GEARING

If you are producing Aerial Cameras—Windshield Wipers—Tape Dispensers—Fire Control Apparatus—Computing Equipment—or many other items where combinations of different Gear types are needed, G.S. Clusters will give you the maximum in precision design. Spurs or Helicals in combination with straight and spiral bevels, spur pinions, worm gears, and clutches are all made with the consistent "better-than-spec" quality for which G.S. is famous all over the country.

Perhaps you have an irksome problem involving such clusters—or some other Small Gearing application. G.S. engineers will be glad to sit down with you and discuss solutions, in the light of our more than four decades of experience in every area of U.S. industry where precision Small Gearing is used in quantity. Why don't you write or phone us—today?

SEND FOR G.S. *illustrated folder! See where and how we mass-manufacture Small Gearing to uniformly fine tolerances. Folder contains 23 pictures of Small Gears, plant view, as well as Diametral and Circular Pitch Tables. Ask for your copy on company stationery, please!*

43 Years of Specializing in Small Gearing!

Circle 412 on Page 19

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Abrasives, Edit. 172
Actuators, Adv. 36
Adhesives, Adv. 68, 235, 255
Aluminum and alloys, Edit. 191, 202; Adv. 67, 78

Balls, Adv. 32
Bars and rod, Adv. 11
Bearing materials, Edit. 171; Adv. inside front cover, 106
Bearings, ball, Adv. 13, 21, 49, 53, 73, 173, 181
  linear motion, Edit. 191
  miniature, Adv. 181
  needle, Adv. 13, 21, 187
  roller, Adv. 13, 21, 57, 64, 187, 197, 199, 211, 215, 220, back cover
  sleeve, Edit. 266
  thrust, Adv. 13, 21, 64, 187
Bellows, Adv. 268
Belts, conveyor, Adv. 68, 189
  transmission, Edit. 135; Adv. 68, 116
Bimetals, Edit. 222; Adv. 205
Blending machines, Edit. 149
Blowers, Edit. 195; Adv. 108, 180, 216, 232
Books, Edit. 254; Adv. 272
Brakes, Adv. 175, 261, 269
Brass (see Copper and alloys)
Bronze (see Copper and alloys)
Bushings, Adv. 106, 268

Cams, Edit. 172; Adv. 187, 211
Capacitors, Edit. 208
Carbides, Adv. 256
Carbon and graphite parts, Edit. 266; Adv. 62
Casters, Edit. 201
Castings, centrifugal, Adv. 87, 183
  die, Adv. 112, 206, 228
  investment, Adv. 44, 236
  iron, Adv. 87, 178, 183
  light alloy, Edit. 171; Adv. 112, 183, 206, 228
  permanent mold, Adv. 206
  shell-molded, Adv. 31
  steel, Adv. 87, 178, 183
Ceramics, Edit. 37, 171, 218, 221
Chain, conveyor, Adv. 120, 213
  transmission, Adv. 45, 191, 193, 195, 213
Clad metals, Adv. 194
Clamps, Adv. 250, 270
Classified ads, Adv. 273
Clutches, Edit. 195; Adv. 84, 102, 175, 261
Coatings, decorative, Edit. 193
  protective, Edit. 36, 171; Adv. 219
Compressors, Adv. 94, 108, 214, 264
Conduit, Edit. 191
Connectors, electric, Edit. 236; Adv. 65, 74, 108, 231, 270
Contacts, Edit. 197; Adv. 194
Control systems, electric, Adv. 130
  hydraulic, Edit. 140, 172; Adv. 27, 83
  pneumatic, Adv. 203
Controls, electric, Edit. 193, 210, 217, 224, 227, 228, 230, 238, 240; Adv. 29, 48, 50, 56, 88, 97, 98, 130, 229, 247, 253, 257
  hydraulic, Edit. 260; Adv. 27, 36, 41, 83, 96, 192, 223, 249, 269
  mechanical, Edit. 136, 152; Adv. 107, 205, 242
  pneumatic, Adv. 36, 203, 223
Converters, Edit. 240
Copper and alloys, Adv. inside front cover, 31, 106
Counters, Edit. 189, 193, 260; Adv. 190, 222, 236
Couplings, fluid, Edit. 210; Adv. 46, 123, 182, 233, 263
  shaft, Edit. 186, 191, 262, 264; Adv. 37, 71, 84, 96, 195, 204, 206, 213, 217, 227, 234
Cylinders, hydraulic, Adv. 83, 109, 113, 223, 269
  pneumatic, Adv. 83, 109, 113, 207, 223

Differentials, gear, Edit. 186
Drafting equipment, Edit. 242; Adv. 61, 81, 239, 262, 267, 269

Electric equipment (see specific type)
Engineering department (see Management or Drafting)
Engines, Edit. 149; Adv. 43, 107
Expanded metals, Adv. 76
Extrusions, Adv. 255

Fabric parts, Adv. 255
Fans, Edit. 189; Adv. 108, 216
Fasteners, bolts, nuts, screws, Edit. 28, 188, 197, 202; Adv. 7, 82, 124, 177, 178, 198, 202, 210, 244, 246, 252, 254
  insert, Adv. 198, 202, 248
  locking, Edit. 188; Adv. 196, 198, 202, 210, 222, 241, 244
  pin, Adv. 177, 241
  retaining rings, Adv. 222
  rivet, Adv. 210, 237, 238
Filters, Edit. 268; Adv. 27, 90, 224, 245
Finishes (see Coatings)
Fittings, pipe, tube, and hose, Edit. 191, 202, 210; Adv. 42, 46, 86, 123, 182, 233, 263, 265
Forgings, Adv. 70, 114
Friction materials, Adv. 68, 226

Gages, etc. (see also Instruments), Adv. 267
Gaskets, Adv. 66, 68, 95, 268
Gears, Edit. 161, 197, 259, 266; Adv. 9, 16, 91, 96, 176, 208, 218, 224
Generators, Edit. 234; Adv. 43, 94
Gyroscopes, Edit. 234

Handles, Edit. 146
Heat exchangers, Edit. 28
Heaters, Adv. 34
Hose, metallic, Adv. 42, 123, 263
  nonmetallic, Adv. 42, 68, 123, 263
Hydraulic equipment (see specific type)

Inspection, Edit. 222
Instruments, Adv. 201, 267

Jacks, worm gear, Edit. 191

Kinematics, Edit. 172

Lenses, Edit. 150
Lubricants, Edit. 171, 218
Lubrication equipment, Edit. 189; Adv. 90

Machines (see specific type)
Magnets, Edit. 40
Management, engineering, Edit. 246
Meetings, Edit. 41
Metals (see specific type)
Microhoning, Edit. 153
Molded organics, Adv. 226
Motor alternators, Adv. 221
Motor bases, Edit. 201
Motors, electric:
  fractional and integral hp, Edit. 221; Adv. 1, 33, 38, 94, 103, 110, 115, 118, 126, 210, 216, 230, 232, 265, inside back cover
  gearmotors, Adv. 100, 110
  subfractional hp, Edit. 238; Adv. 267
Motors, hydraulic, Adv. 249
  pneumatic, Adv. 207, 212, 214

Packings, Adv. 66, 68, 245
Patents, Edit. 137
Physical measurements, Edit. 172
Pillow blocks, Adv. 49, 173
Plastic foams, Edit. 226
Plastics, Edit. 186, 188, 195; Adv. 32, 68, 77, 189
  laminates, Edit. 236; Adv. 40, 104, 170
  moldings, Edit. 214; Adv. 68, 104, 188

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Plugs, Edit. 236; Adv. 65, 74, 108, 121, 231, 270
Pneumatic equipment (see specific type)
Potentiometers, Edit. 199, 214, 232
Powder metallurgy, Adv. inside front cover, 62, 92, 106
Processing equipment, Adv. 228, 240, 258, 267
Product models, Edit. 132
Pulleys (see also Sheaves), Adv. 15, 116, 206
Pumps, hydraulic, Adv. 94, 122, 192, 209, 234, 249, 270
pneumatic, Adv. 214

Reducers, speed, Edit. 191, 199; Adv. 1, 33, 91, 96, 100, 218, 266
Regulators, flow, Edit. 260; Adv. 27, 86
Relays, Edit. 210, 217, 224, 228, 240; Adv. 56, 88, 257
Research and development, Edit. 30
Resistors, Edit. 193, 199
Rifles, Edit. 22
Rubber, Edit. 171; Adv. 52, 68, 77, 125, 255
Rubber molding, Adv. 68, 245, 255

Seals, Edit. 259; Adv. 2, 66, 68, 235, 238, 245, 254, 255, 265, 268
mechanical, Adv. 66
Servomotors, Edit. 206, 224
Shafts, flexible, Adv. 242
Shapes, special, Adv. inside front cover, 188
Sheaves (see also Pulleys), Adv. 116, 206
Small parts, Adv. inside front cover, 185, 188
Solenoids, Adv. 86, 184, 229, 253, 260
Spin forgings, Edit. 32
Springs, Edit. 165, 206
Sprockets, Edit. 193; Adv. 213
Steel, Adv. 11, 54, 72, 99, 128, 200
stainless, Adv. 11, 92
Switches, Edit. 186, 189, 195, 205, 213, 217, 227, 230, 238; Adv. 29, 48, 97, 98, 130, 229, 253
Swivel joints, Adv. 46

Tape, Adv. 194, 255
Terminals, Edit. 226; Adv. 258
Testing, Edit. 244
Thermal stresses, Edit. 156
Thermostats, Edit. 199
Timers, Edit. 186, 210; Adv. 56, 236
Tips and techniques, Edit. 139, 145, 169
Titanium and alloys, Adv. 92, 256
Torque converters, Adv. 230
Transformers, Edit. 227
Transistors, Edit. 230
Transmissions, adjustable speed, Edit. 268
Tubing, Edit. 202, 264; Adv. 5, 54, 68, 104, 251

Universal joints, Adv. 37, 217, 234

Vacuum melted alloys, Adv. 243
Valves, hydraulic, Edit. 197, 205, 213, 260; Adv. 27, 41, 75, 184, 233, 249, 260, 265, 274
pneumatic, Edit. 197; Adv. 41, 203, 207, 260, 274

Wire and wire products, Edit. 206; Adv. 225, 259
Wood, Adv. 80

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE— descriptions start on page 174

	ITEM NUMBER
Integral Shaft Sheaves	625
Dial Thermometers	626
Pillow Block Bearings	627
Centrifugal Castings	628
Washers & Stampings	629
Vibration Isolators	630
Aircraft Fueling Systems	631
Blind Rivets	632
Center Shock Mountings	633
Enclosed Switches	634
Precision Gears	635
Silicones Guide	636
Office Copying Techniques	637
AC Generators	638
Sight Flow Indicators	639
Gearmotors	640
Swivel Pipe Joint	641
Cable Assemblies	642
Casters & Wheels	643
Hose Assemblies	644
Aluminum Mill Products	645
Stud Welding	646
Teflon Cylinders & Tubing	647
Tool & Die Steel	648
Industrial Fasteners	649
Thermal Insulation	650
Fittings & Flanges	651
Printed Circuit Connectors	652
Alloy Steel Castings	653
Blowers & Exhausters	654
Precision Castings	655
Carbon-Graphite	656
Sheet Metal Fabrication	657
High Voltage Controls	658
Rigid Plastic Fans	659
Corrosion Resistant Alloys	660
Tubing	661
Flexible Metal Hose	662
Power Transmission Equipment	663
Piston Seals	664
Insulating Plastics	665
Welded Steel Tubing	666
Fasteners & Tools	667
Rotary Pumps	668
Adhesives, Coatings, Sealers	669
Turbine-Generators	670
Alloy Wire Cloth	671
Ball Screwjack Assemblies	672
Power Supplies	673
Automatic Air Filter	674
Converter-Inverters	675
Forging Facilities	676
Elastomer	677
Industrial Truck Batteries	678
Aluminum Alloy	679
Cartridge Type Heater	680

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 186

	ITEM NUMBER
Miniature Differentials	681
Free-Aligning Coupling	682
Timing Motors	683
Translucent Plastic Panels	684
Pushbutton Switch	685
Encapsulating Resin	686
Lightweight Lock Nut	687
Miniature Fan	688
Mechanical Counter	689
Miniature Switch-Transducer	690
Adjustable Couplings	691
Miniature Speed Changer	692
Aluminum Conduit	693
Ball Screwjacks	694
Variable Resistor	695
Sprocket Assemblies	696
Metallic Foil Flake	697
Pickup Units	698
Nylon Blower Wheels	699
Centrifugal Clutch	700
Miniature Inertia Switches	701
Plug Valve	702
Floating Spacer Nut	703
Precision Gears	704
Slip Ring and Brush Assembly	705
Thermostats	706
Ten-Turn Potentiometer	707
Gear-Reducer Combination	708
Precision Resistors	709
Tilting Motor Base	710
Heavy-Duty Caster	711
Aluminum Pipe	712
Carriage & Machine Bolts	713
Spring-Return Switch	714
Gate Valves	715
Servomotors	716
Spring Wire	717
Tantalum Capacitors	718
Disconnect Coupler	719
Time-Delay Relay	720
Switch-Light	721
Ball Valves	722
Epoxy Molding Powder	723
Miniature Potentiometer	724
Telephone-Type Relay	725
Drum Switch	726
Solid-Film Lubricant	727
Ceramic Transducer Element	728
Single-Phase Motors	729
Hermetically Sealed Headers	730
Proximity Pickup	731
Composite Metal	732
Control Relays	733
Servomotor	734
Diode Clips	735
Self-Adhesive Foam	736
Differential Transformers	737
Acceleration Switch	738
Meter-Relay	739
Pushbutton Station	740
Hook Switch	741
Alloy-Junction Transistor	742
Miniature Potentiometers	743
Motor-Generator	744
Rate Gyroscope	745
Phenolic Laminate	746
Miniature Hex Connectors	747
Mercury Switch	748
Shaded-Pole Motors	749
Transistorized Converters	750
Heavy-Duty Power Relay	751
Rolling Ruler	752
Portable Planimeter	753
Oscillographs	754

MACHINE DESIGN
FEB. 19, 1959

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Apr. 19, 1959

MACHINE DESIGN
FEB. 19, 1959

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Apr. 19, 1959

MACHINE DESIGN
FEB. 19, 1959

Circle item number for information on products advertised or described or copies of literature.

401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
407	432	457	482	507	532	557	582	607	632	657	682	707	732	757
408	433	458	483	508	533	558	583	608	633	658	683	708	733	758
409	434	459	484	509	534	559	584	609	634	659	684	709	734	759
410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
415	440	465	490	515	540	565	590	615	640	665	690	715	740	765
416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
420	445	470	495	520	545	570	595	620	645	670	695	720	745	770
421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
424	449	474	499	524	549	574	599	624	649	674	699	724	749	774
425	450	475	500	525	550	575	600	625	650	675	700	725	750	775

SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

Page No. — Title of Article

....

....

....

....

CARD INVALID WITHOUT COMPANY NAME — TYPE OR PRINT

NAME _____

TITLE _____

COMPANY _____

PRODUCT MANUFACTURED _____

ADDRESS _____

CITY _____ ZONE____

STATE _____

Do not use this card after Apr. 19, 1959

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.

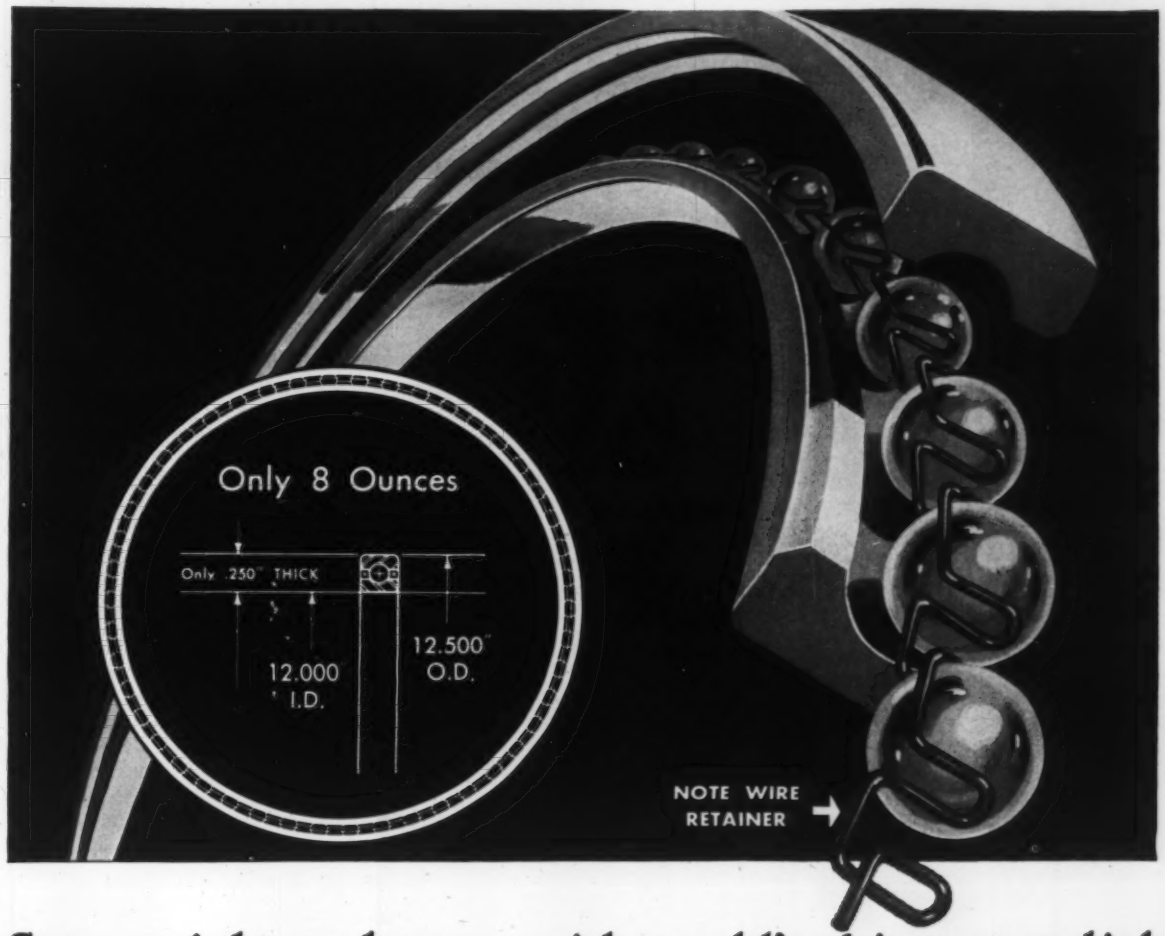
FIRST CLASS
Permit No. 36
CLEVELAND, OHIO

BUSINESS REPLY CARD
No Postage Stamp Necessary if Mailed in the United States

POSTAGE WILL BE PAID BY—

MACHINE DESIGN
Penton Building
Cleveland 13, Ohio

Reader's Service Dept.



Save weight and space with world's thinnest radial ball bearings—*Reali-Slim* by Kaydon

. . . now carried in stock in 4" to 12" bores

HERE it is! A *Reali-Slim* radial ball bearing with a wire separator that has just short of a full complement of balls for maximum capacity. What's more, you still get all the advantages of a separator between the balls. This design also gives you a bearing that's light-in-weight and is, without a question, the thinnest bearing ever built in this diameter.

Whatever your product design, there's a small or large diameter *Reali-Slim* bearing that can be the right answer to your thin-section bearing problems.

The radial ball bearing, illustrated here, is *really slim* — 12.000" I.D., 12.500" O.D., .250" thick . . . *and weighs only eight ounces.* It has 9,810 lbs. static load capacity, 1,256 lbs. at 100 rpm. Kaydon is able to produce *Reali-Slim*, high-precision bearings because Kaydon specializes in the unusual.

Kaydon bearing engineers are prepared to give you valuable help with technical, thin-section bearing problems.

For detailed information on Kaydon's *Reali-Slim* line, ask for engineering catalog No. 54-RS3 detailing:

Reali-Slim Ball Bearings — Conrad, angular contact and 4-point contact types in seven standard cross sections from ¼" to 1.000" and in bore diameters from 4" to 40".

Reali-Slim Roller Bearings — Radial and taper roller types in cross sections from 9/16" and in bore diameters from 5" to 40".

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

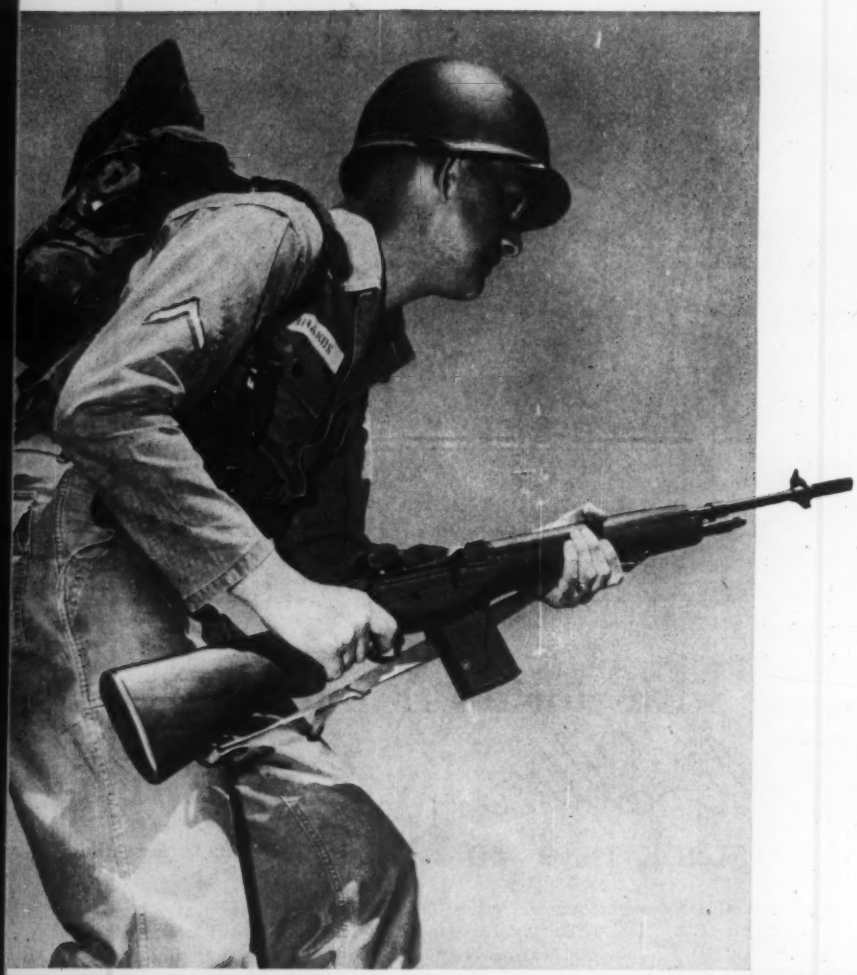
K-561R

All types of ball and roller bearings — 4" bore to 178" outside diameter . . .

Taper Roller • Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust Bearings

Circle 413 on Page 19

What's so tough about

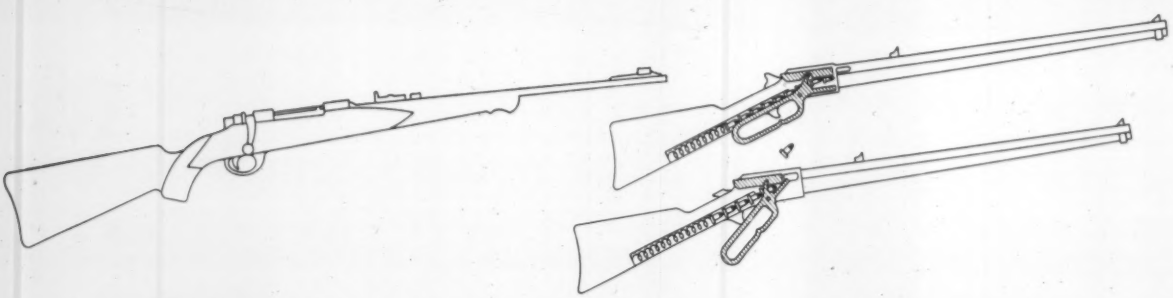


IN 1903, Winchester Repeating Arms Co. offered the first successful autoloading rifle in America. Thirty-six years later, in 1939, the M1 was adopted as the standard infantry rifle. Tommy guns, Bren guns, BARs, and countless automatic shotguns, rifles, and pistols had been fired by sportsmen, service men, gangsters, and G-men between those dates with presumably satisfactory results. Why did the infantryman slog along with the 1903 Springfield for so long?

Twenty years later infantrymen are still slogging along with the M 1. The Army is slowly introducing another new rifle—the M14. Why the delay? What's so tough about designing an Army rifle?

Let's see what a designer faces in designing any rifle

The rifleman asks him to furnish mass for inertia, strength, and heat dissipation; and at the same time light weight for maneuverability. He asks for high muzzle velocity for flat trajectory, and energy for killing power; but he wants light cartridges so he can carry plenty of them.



Bolt Action

Lever Action

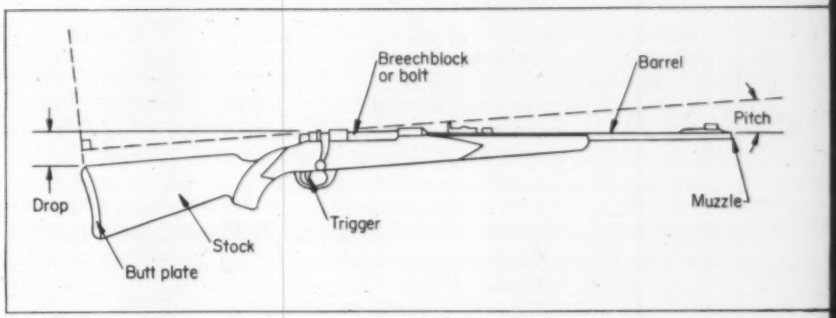
designing an Army rifle?

He wants an action that works smoothly without jamming, hot or cold, on all the varieties of ammunition he will put into it, but he is not willing to sacrifice accuracy to get the sloppy fit necessary to accommodate the largest of this ammunition. Quality materials for corrosion resistance and increased strength are a must on his list; but he also wants low-priced materials, and, in the case of the Army, materials that are not scarce in wartime.

To aim his rifle easily, he wants a low, angled stock that lets him get his eye down to sight close over the barrel, but to hold the gun steady, he would rather have a high, straight stock.

In planning the barrel, the designer must know the cartridge that's going into it. Where does the bullet reach peak velocity? That's where the muzzle should stop. With high-energy powders, 22 in. is usually long enough for a barrel nowadays; more length would be likely to detract rather than add to the efficiency and accuracy of the rifle.

What about rifling? For every weight of bullet, there is an optimum spin rate for gyroscopic stability. Knowing the weight of the bullet, the designer can find this spin rate, and then, if expected muzzle velocity of the bullet is known, he can decide what pitch of rifling lands will give this spin. All rifles have certain limits on the weight and velocity of the balls used in them, imposed by the design of the rifling.

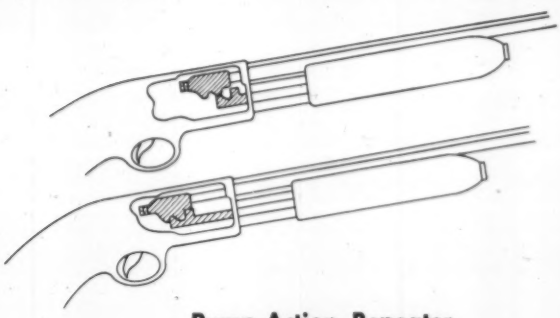


Old Springfield '03 sets high design standards for future rifles

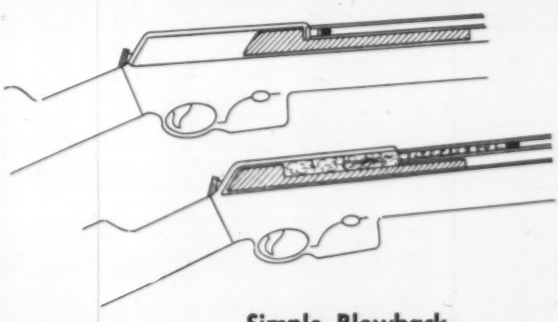
The Springfield 1903 was a happy compromise on many of these points. Ornery as a mule in the hands of a greenhorn, it is still considered a marksman's rifle. Recoil was apt to slap the comb against the unwary novice's cheek, but its medium 9-lb weight and its moderately straight stock held it steady enough for a good marksman to make a 1-in. diam pattern of ten shots at 100 yd.

The Mauser-type bolt action, although slower than other repeating actions like the lever action and the pump action, was one of the strongest built. Two heavy lugs up near the receiver held the closure firmly during firing. Being close to the source of stress, they gave little chance for elastic deformation.

A strong camming action on the head of the cartridge during ro-



Pump-Action Repeater



Simple Blowback

For Snipers . . . Cannon or Peashooter?

How much weight is needed for accuracy in a rifle? Many experts have claimed that 9 or 10 lb are necessary. The Army has investigated designs that are as light as 6 or 7 lb. The Fairchild survival rifle adopted by the Air Force weighs only 2 lb 6 oz, but its makers claim for it a range of only 250 yd. Fairchild has also developed a "Parasniper" rifle chambered for the .308W. Savage has developed a new 6¾-lb hunting rifle, model 110, which can be chambered for the 30-06. Although the company makes no claim for this rifle, twenty 85-grain Sierra bullets in a 243 cal version, achieved a spread of only 0.978 in. at 100 yd.

The 6¾-lb Savage 110 can crack a 1-min dispersion angle as well as heavier guns. It is strong enough to shoot the 30-06 cartridge. A locking nut on the barrel allows headspace to be adjusted when barrels are changed.

The Fairchild survival rifle weighs only 2 lb 6 oz. It fires four rounds from a clip. Its effective range of 250 yd is obviously unsuited for Army use.

Light weight Fairchild automatic rifle, AR-10, has aluminum barrel. Straight stock means steadiness under rapid fire, but notice the high sights. Gas-operated action is latched open after the last shot. It weighs 6.85 lb.

tation of the bolt before drawing back, made one of the strongest primary ejection systems seen, with little chance of tearing through the flange of the cartridge case. For this reason, tolerances could be held pretty close without fear that an oversize shell would stick immovably in a hot gun.

Headspace in a new Springfield 1903 was held between 1.940 and 1.943 in. No rifle was kept in service after headspace became 1.950 in. Training to use the Springfield was fairly simple, and it could be field-stripped and assembled with the aid of no tools but a cartridge.

Any autoloading rifle, to win acceptance in the Army, must nearly equal these advantages of the Springfield, as well as adding its own simplicity of operation and faster rate of fire. None of the early autoloaders matched these characteristics.

The Army pictures the infantryman as a trigger-squeezing bullet-miser. In other words, important as it is, rapidity of fire is still second to accuracy.

The Springfield stock, though straight, had enough pitch and drop for easy sighting close to the barrel. Any weapon with a stock like the Springfield's can be used for fairly fast semiautomatic fire, since recovery is quick, but it will not do for full automatic fire.

A straight stock is necessary for full automatic fire, or else the couple formed by the recoil of the gun along the axis of the barrel and the reaction of the gunner's shoulder against the butt will turn the muzzle up farther and farther at each shot. Straight-stocked rifles like the British EM 2 have sights necessarily set far above the barrel, as do most machine guns. This is contrary to design standards necessary for U. S. principles of sharpshooting.

Semiautomatic rifles can be classed as blowback, recoil, and gas-operated

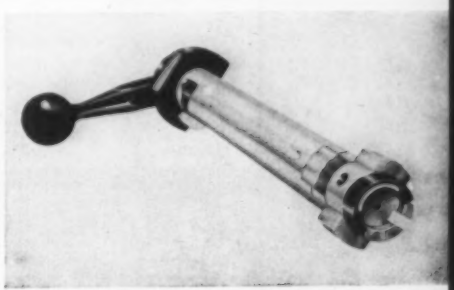
The 1903 Winchester autoloader used the simple "blowback" design where pressure from the burning powder gases not only propelled the bullet out of the muzzle, but pushed cartridge case and breechblock back at the same time. The cartridge case was pushed out of the gun by the next cartridge when it cleared the breech. The new cartridge moved into line with the breechblock. The counter-recoil spring returned the breechblock, which pushed the cartridge home in the chamber.

Since the breechblock could not be positively locked with this system, the only assurance that the breech would not open dangerously, allowing hot, high-pressure gases to blast the shooter's face, was the great inertia of the breechblock compared to that of the bullet, and the strength of the counter-recoil spring. These were balanced in such a ratio that the bullet was just leaving the muzzle and the pressure had dropped to a safe level before the breech opened to a significant degree. To organize the same ratio for a cartridge like the 30-06 would take a breechblock weighing 27 lb!

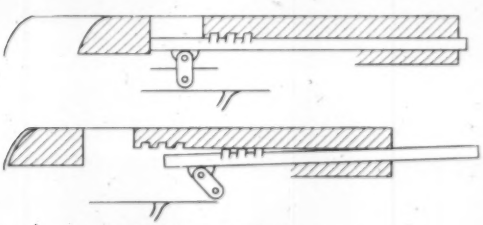
Retarded blowback actions attempted to overcome this problem by using toggles, cams, or inclined planes to slow the blowback without the need for so much mass in the breechblock. The .276 Pederson rifle used the toggle system. Two links behind the breechblock are not quite straight when the breech is fully closed. Being nearly straight, they resist the high acceleration of the hot gas pushing the block open. As the block moves back, the toggle is collapsed, allowing free backward motion from momentum at the end of the stroke when the pressure of the gas is dissipated.

Otherwise, the action is the same as that previously described. Sloping lands, which lock the bolt and force it to rotate as it opens, do much the same type of job on the Thompson submachine gun. Since the block starts to move back in these types as the gun is fired, a sticking cartridge case is apt to split; so lubricated ammunition is recommended.

Recoil action patented by Browning followed close on the heels of Winchester's blowback action. For many years after Browning, Remington Arms Co. continued to make autoloading shotguns using this ac-

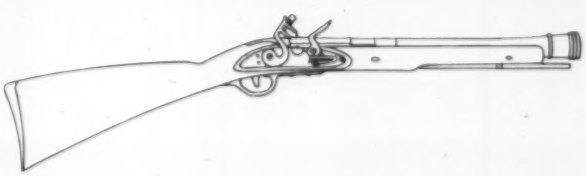


Heavy locking lugs on bolt of the Savage 110 show how that rifle has kept and improved one of the most attractive features of the Mauser action. Elasticity of the bolt shank is not a consideration in this design since stress passes directly from bolt face to the locking lugs, leaving the main body unstressed.



Colt-45 action . . .

uses this short-recoil mechanism for unlocking breechblock and barrel.



Early blunderbuss . . .

places shoulder reaction well below line of recoil. Such a gun kicks violently.

tion.

Here, for the first time in automatic actions, the breech remains tightly locked during the critical firing phase. Barrel and breechblock move backward together. The breechblock is held by a catch at the rear, while a cam unlocks the barrel which moves forward, impelled by its own return spring. Locked to the breechblock by a hook, the cartridge is dragged out of the chamber. Near the end of its forward journey, the barrel trips the catch holding the block. As it moves forward, the block pushes the top cartridge from the magazine into the receiver. Army disapproval noted the moving barrel on which sights could not be fixed; weight; and number of parts.

Winchester re-entered the field at the start of World War II with a gas-operated piston. High-pressure gas from directly in front of the receiver would have made a violent action that tore cartridges and gave guns excessive wear. So Winchester's model actuated a piston that moved only $\frac{1}{8}$ in. to strike a lever that continued to move under momentum to operate the mechanism. This action was used in the M1 carbine.

The other successful gas-operated autoloader of World War II in the U. S. Army was the M1 rifle, popularly called the Garand after its inventor. This gun initiated the principle of bleeding gas from the muzzle end of the gun, where pressure was much lower but still sufficient to operate the breech action surely. The hooded sights have a wider range of vision, but less accuracy than the Springfield's.

The M14 follows much the same principle, but gas is bled from a little farther back than in the M1. The stock is still a modified straight stock, much like the Springfield. The ammunition is no longer the 30-06, but now the NATO 7.6-mm cartridge. A muzzle brake has been added along with a flash suppressor. This is the result of 15 years development from the M1.

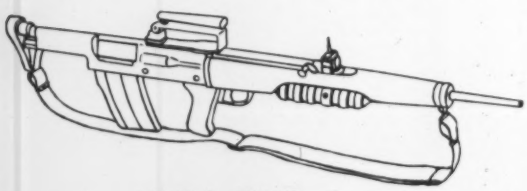
Future Design—Old Problems

Problems faced by designers of automatic weapons are the same as problems faced by designers of the M1:

- Weight.
- Complicated design.
- Reliability.
- Accuracy.
- Ability to take dirt and abuse.

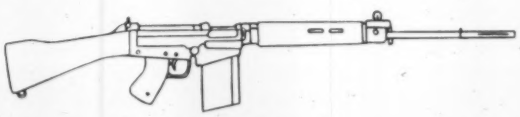
Five years will build a jet engine from scratch. Five years will put a satellite in orbit. Five years is about the lead time Detroit gives itself for a new car. But a gun is tricky business.—T. M. LEACH

Straight stocks brace a gun well in full automatic fire. The AR10 and the M60 are designed to be steady under rapid fire. High setting of sights introduces parallax which must be compensated.



British EM 2 . . .

is braced against recoil with shoulder butt on the line of recoil thrust.



Belgian FN . . .

shows modified stock favored by U. S.

Space and the Future: Another (two-part) Prediction

LOS ANGELES—With ballistic missiles in an advanced state of development, new technologies which have evolved along the way can now be used to make many dramatic devices besides missiles and run-of-the-mill satellites. Dr. R. A. Cornog, head of the Space Physics Group of Ramo-Wooldridge's Space Technology Lab, looked into the future recently and described some sure-fire developments scheduled for no later than the year 2000. He points out that the ICBM programs are now on the brink of developing the four essential requirements for full-scale space travel:

- Reliable, high-performance rocket engines
- Safe, stable re-entry vehicles
- Lightweight structures capable of carrying loads 100 times their own weight
- Simple and reliable guidance equipment

With these major items available, Dr. Cornog predicts that:

In 10 years . . .

there will be cheap intercontinental transportation at hypersonic speeds. Passengers will travel from Los Angeles to Paris in 1 hr. Cost should not be more than $100. A second probable development will be a world-wide communication and color TV system, with transmitting equipment housed in satellite vehicles. Even TV commercials may have considerable cultural value, according to Dr. Cornog. An international public that learned to withstand TV verbal pressures would be less likely to succumb to misleading political propaganda.

In 50 years . . .

fairly large colonies of people will be settled on the moon and on other bodies in the solar system. These colonies will be completely self-sustaining. A similar civilization may inhabit a synthetic planet.

Using a simple two-stage carrier vehicle, with both stages recoverable, it will be possible to place a payload in orbit at a cost of $1000 per ton (50¢ per lb). A million-ton vehicle, built in small segments like the pyramids, would cost only $1,000,000.

HYDRAULIC SYSTEM DESIGN IS EASIER WHEN THE CONTROL ZONE IS WATERMAN

Waterman Valves and Accessories for Hydraulic Systems

Flow Regulators

Solenoid Valves

Filters

Check Valves

Pilot Checks

Waterman Series 190 pressure compensated flow regulators are the simple, straightforward way to be sure of constant cylinder speed, regardless of load. Factory-set to your specifications, factory-tested for precise calibration. Easiest of all to design into a system, because they require no access for adjustment, take little more space than the pipe or tubing that they replace. Rated at 3000 p.s.i., controlled flow rates from 0.1 to 100 g.p.m. Matched pairs and sets available.

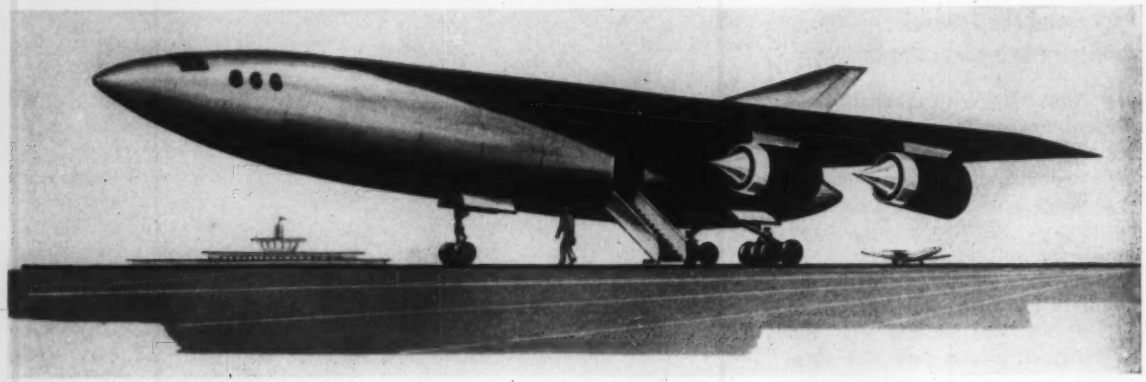
Series 190 is just one of many Waterman types that make up the most complete line of hydraulic flow regulators—fixed and adjustable. Specify Waterman for flow control and be *right—from the start.*

W-5908 **Waterman representatives are in all principal cities. Write for Waterman Flow Regulator Catalog No. 1000, and for Waterman Solenoid Valve Catalog No. 2000.** Also suppliers of AN and MS qualified flow regulators and fuses.

Waterman Engineering Company, 725 Custer Ave., Evanston, Illinois

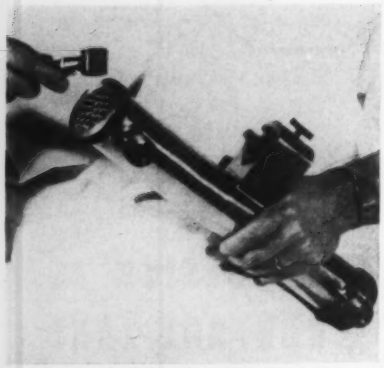
WATERMAN ENGINEERING COMPANY

Circle 414 on Page 19



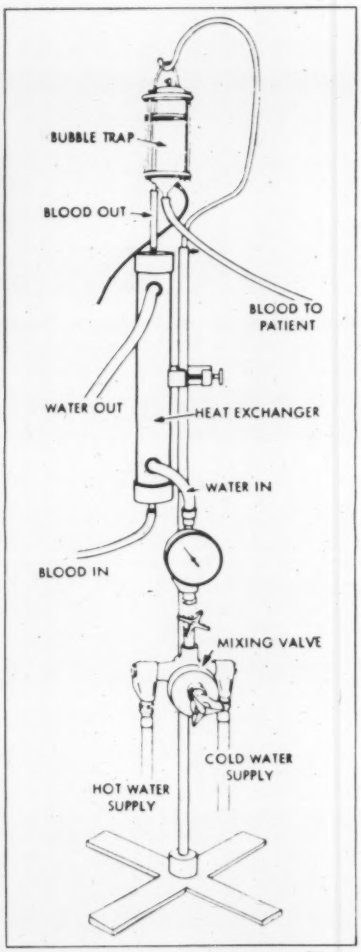
Mach-4 Transport

Ramjet-powered commercial aircraft are feasible on the basis of current engineering know-how, according to the Marquardt Aircraft Co. In recent ground tests, a Marquardt engine showed reliable operation and satisfactory fuel consumption at simulated altitudes of 14 mi and speeds of more than Mach 4. The test engine ran continuously for 50 hr—equivalent to a nonstop circuit five times around the earth. Marquardt's hypothetical transport weighs 300,000 lb (approximate weight of current jet transports) and is designed to carry 100 passengers. Afterburning turbojets would supply takeoff power and acceleration to Mach 2 at 30,000 ft. Ramjets would then take over for climb and acceleration to an ideal cruise regime of Mach 4 and 80,000 ft.



Blood Radiator

Blood runs cooler during delicate heart surgery with a stainless-steel heat exchanger developed by GM's Harrison Radiator Div. Reducing a patient's blood temperature also reduces his body temperature, resulting in lower oxygen requirements and slower blood-flow rates through the heart and other vital organs. Core of the heat exchanger is a cluster of 24 stainless-steel (type 304) tubes with highly polished inside surfaces. Blood flows through the tubes and is cooled, or warmed after the operation is over, by a parallel flow of water in the surrounding jacket. Bubbles in the blood are caught in a trap at the exchanger top. The unique blood radiator permits body temperature to be lowered 10 deg in 5 min, returned to normal in 10 to 15 min. Previous ice-pack and blanket methods required 5 to 6 hr for the cooling and warming process.



First Standard 1600-F Bolts Available in Advanced Alloys

JENKINTOWN, PA.—Standard structural fasteners for use at temperatures up to 1600 F are now being produced by Standard Pressed Steel Co. Highest operating temperature for any previous standard aircraft bolt was 1200 F.

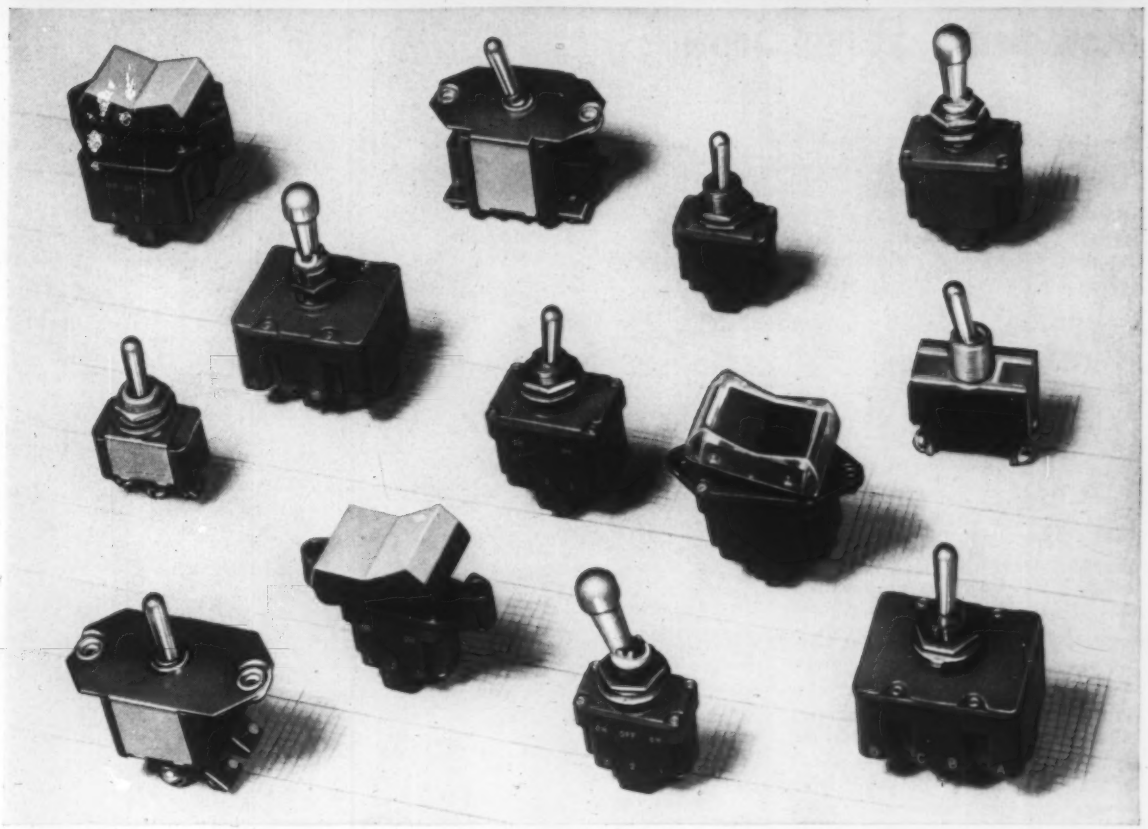
Offered in both airframe and engine-bolt configurations, the high-temperature fasteners are fabricated from any of four advanced alloys: M-252, Waspalloy, Udimet 500, and Hastelloy R-235.

Though developed primarily for aircraft, jet-engine, missile, and rocket needs, the 1600-F fasteners—literally red-hot in use—presumably could find application in gas and steam turbines and related fields.

Minimum tensile strength of the bolts is 155,000 psi at room temperature, 135,000 psi at 1200 F, and 85,000 psi at 1600 F. Rated minimum stress-rupture life is 100 hr at 1500 F and 10 hr at 1600 F—in both cases with sustained loads of 30,000 psi.

Both engine and airframe bolt series are external-wrenching types with 12-point configurations. The EWB 1615 airframe tension bolts are of NAS 624 configuration, and the BE 1615 engine bolts are type MS 9033 configuration. Initially, SPS will produce 1600-F bolts in sizes No. 6 through 1½ in. diam.

MICRO SWITCH Precision Switches



Toggle and rocker actuated switches that provide better answers to a variety of switching problems

This group of thirteen switches represents well over seven hundred switches in three series. There's a complete selection of contact arrangements, mounting provisions, and choice of single, double, or 4-pole construction.

"TP" Series—rocker actuated, sealed actuator and cover. Available with translucent keys for use with edge-lighted panels to give visual indication of position, or with transparent keys that permit insertion of labels. Integral terminals. These switches promote neat panel appearance. Data Sheet 141.

"TL" Series—toggle switches with sealed actuators and covers. Meet Specification MIL-S-3950A. Integral terminals. Diallyl phthalate cases reduce carbon tracking at altitude, and minimize moisture absorption. Series includes pull-to-unlock toggles, with a positive lever lock that requires a definite pull to change toggle position. Knobbed levers permit use with gloved hands. Data Sheets 139 and 142.

"TS" Series—toggle switches that meet Specification MIL-S-3950A and, *in addition*, offer outstanding features. Sealed toggle lever. Riveted solid silver contacts. Maximum over-surface creepage and clearance distances. Momentary versions are built without return springs in order to eliminate a source of early failure. Described in Catalog 73—which also includes miniature and subminiature toggle switch assemblies.

All these switches are manufactured with extreme care and precision from the finest materials, with due regard for important details that mean easier mounting and wiring, and longer switch life.

Send for Data Sheets and Catalogs listed above. Engineering assistance on switch applications is available from the MICRO SWITCH branch office near you.

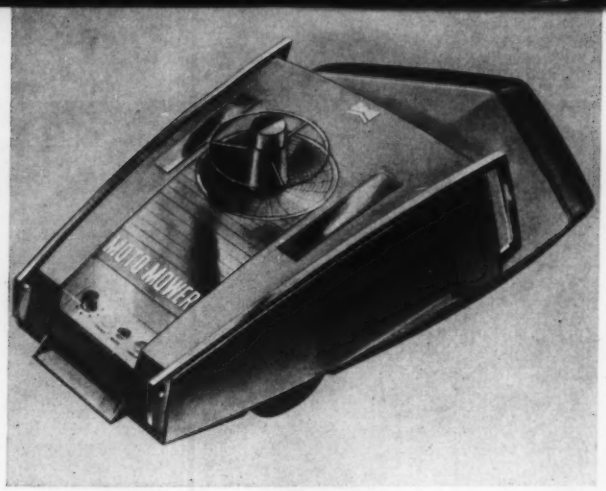
MICRO SWITCH . . . FREEPORT, ILLINOIS
A division of Honeywell
In Canada: Honeywell Controls Limited, Toronto 17, Ontario

Honeywell
MICRO SWITCH PRECISION SWITCHES

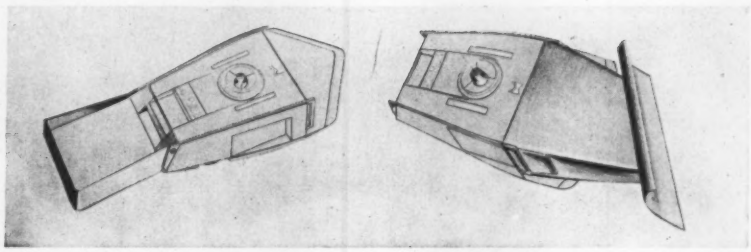
Circle 415 on Page 19

Robot Gardener: Circa 1969

Sun-Powered Slave Will Mow Grass, Shovel Snow



Mower leaves its storage to start mowing cycle on signal from electric eye. Cycle is directed by remote-control from antenna on storage unit. Large cone surrounding the antenna rod rotates with sun, collects solar energy to charge battery.



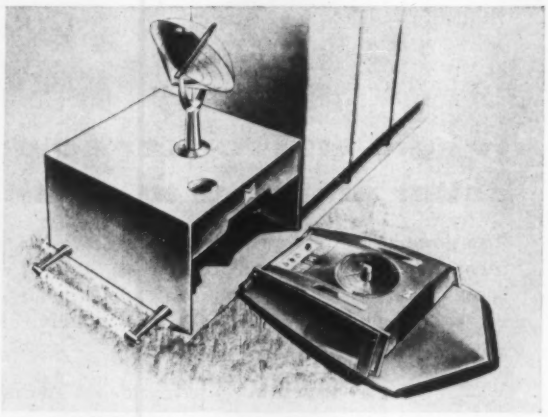
Attachments fit unit to plow snow or collect grass cuttings.

TAPE-PROGRAMMED remote controls will operate the solar-powered mower of 1969, predicts Moto-Mower Inc., Richmond, Ind. Sequence will be triggered by an adjustable electric eye that senses height of grass. If grass is wet, a moisture detector short circuits the action. Vee-shaped bumper will actuate controls to steer right or left around obstacles. Power for the mower will come from storage batteries recharged by sunlight while not in use.

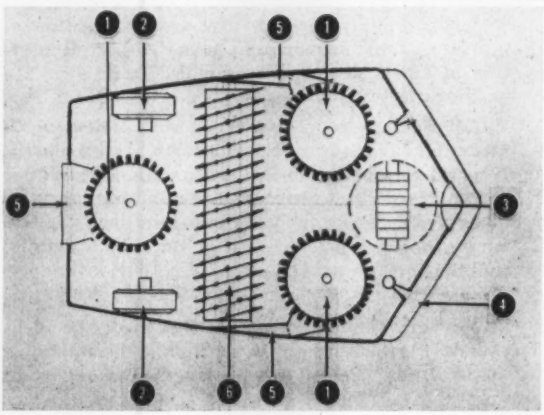
How the device will pick up toys, rocks, croquet wickets, and lawn chairs has not yet been disclosed. The chief remaining problem seems to be how to help the machine decide what would be moved and what should be mowed around.

In winter, a switch in tape programs will convert the machine to a power snowplow to clean walks and drives. Another program change adapts the machine to spread fertilizer which is rolled in with a spiked roller that aerates the soil as it works.

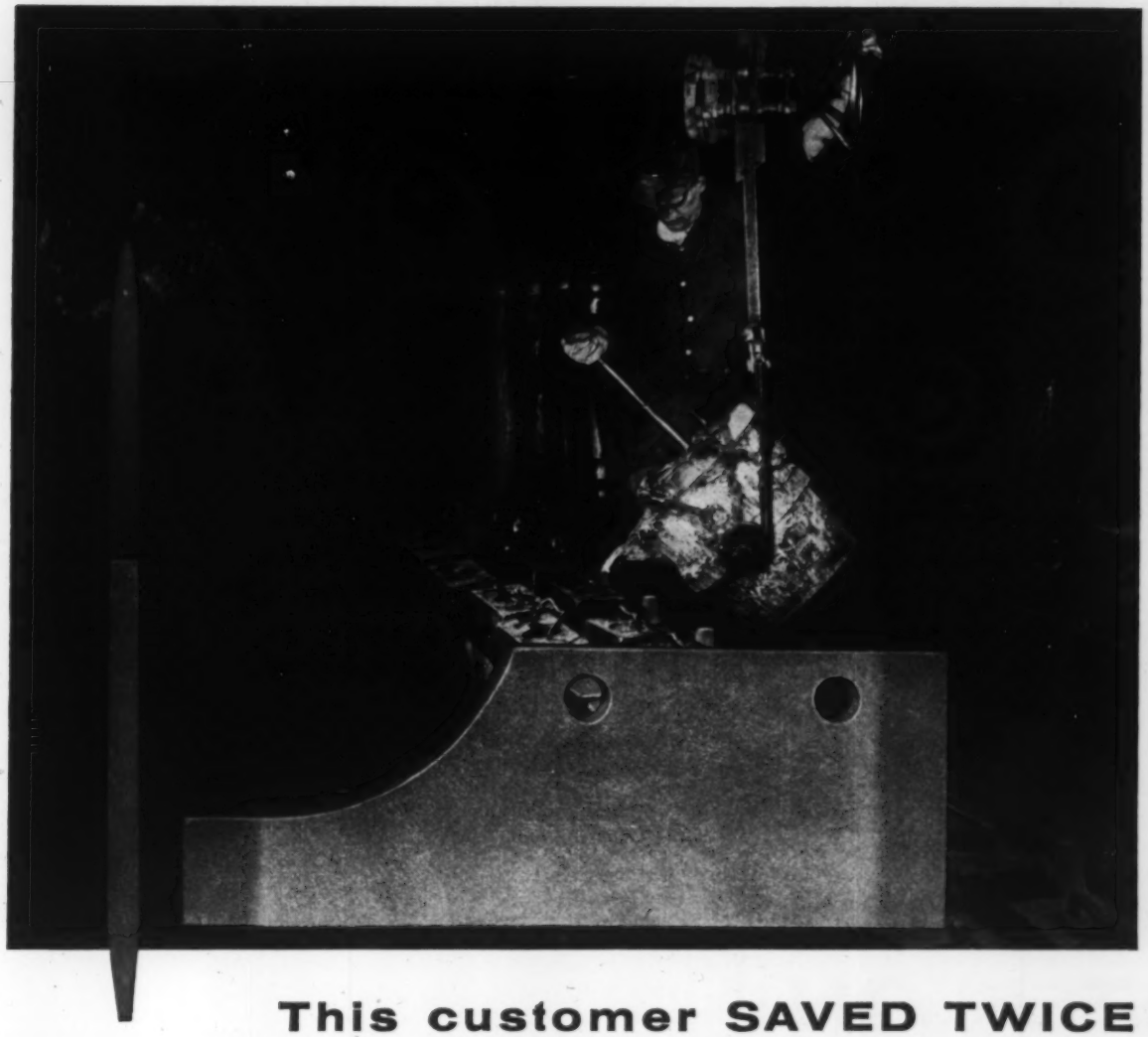
Cutting is done by three overlapping, toothed, shearing discs like those seen in some electric shavers today. Vents on back and sides may be used individually or in any combination to eject grass. Driver's seat and handlebars are missing, but a small control panel on the mower allows program changes, adjustments in cutting height and speed, and signals malfunctions.



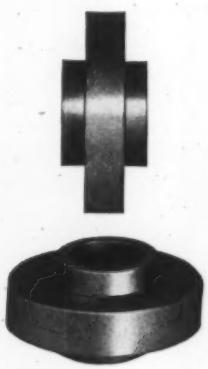
Wheel-like antenna atop mower receives instructions from remote control unit. Program changes or additions can be made from instrument panel on back of mower.



1. Rotary toothed shearing discs.
2. Rear (driving) wheels.
3. Steering roller-wheel at front (pivots 180 degrees).
4. Bumper (actuates course changes).
5. Exhaust ports for clippings.
6. Built-in roller with short spikes to aerate the ground.



This customer SAVED TWICE with Ampco Shell Moldings



Gear blank shell-cast in Ampcoloy nickel bronze. Surface finish was held to ± .015. Only finishing required was to hob teeth and broach key-way. Savings were considerable.

In the wear strip above, shell-cast of Ampco Metal, all dimensions including end-bevels and hole locations were held to ±.015. The smooth surface finish required no machining. Substantial savings of time and money were realized.

With Ampco Shell Moldings, castings can be held to extremely favorable tolerances. Finishing operations are often eliminated; less metal is wasted. More of the tough outer cast shell is retained, providing longer service life.

Casting detail is excellent — oil grooves, deep pockets, and recesses can be cast in, and coring is close and precise, for complex designs impractical by other methods. High production rates reduce molding costs.

Ampco Shell Moldings are available in an extremely wide range of copper-base alloys. Ask an Ampco field engineer to tell you more about this money-saving production process. And write for Bulletin G36-957. *Ampco Metal, Inc., Dept. 30-D, Milwaukee 46, Wisconsin. (West Coast Plant: Burbank, Calif. — Southwest: Garland [Dallas County], Texas)*

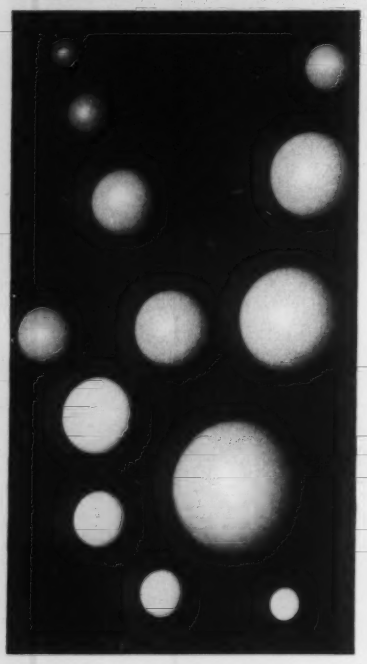
G-18

AMPCO

ONE-SOURCE SERVICE FROM RAW MATERIAL TO FINISHED PRODUCT

Circle 416 on Page 19

CLEAN AND CLEAR BALLS



OF NYLON AND TEFLON

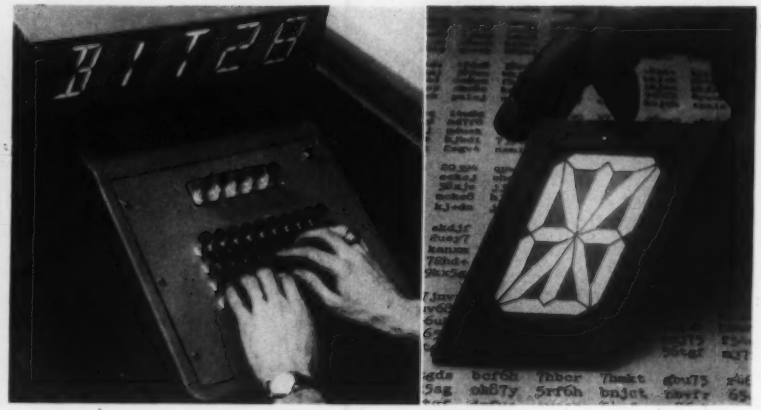
Because of improved grinding and finishing methods, ITI Nylon and Teflon balls are FREE OF EMBEDDED SURFACE GRIT. Their clean, clear finish assures THE BEST in performance for your products.

These balls are available in all sizes — standard (carried in stock) and special. Samples free on letterhead request.

Write **for prices and specifications.**

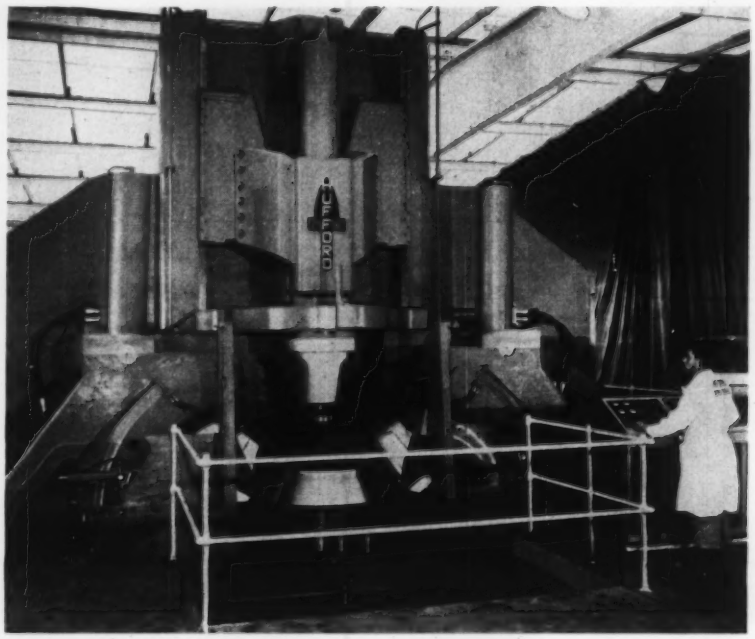
ITI
INDUSTRIAL TECTONICS, Inc.
MANUFACTURERS OF PRECISION BALLS AND BEARINGS
3663 Jackson Road, Ann Arbor, Michigan

Circle 417 on Page 19



Flat Lamp Prints Full Round of Letters, Numbers for Readout

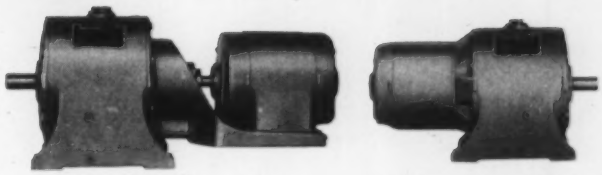
Segments of an electroluminescent panel light in patterns selected through control circuits to form letters and numbers. Solid-state panels, designed by Westinghouse Electric Corp., Pittsburgh, plug into an especially designed receptacle. Total thickness is 1 in. Available for 240 or 460 v, 60 to 400 cps circuits, lamps can be installed with standard components in scoreboards, dispatching boards or other transient displays. They draw only 0.2 w with all elements lighted. Standard 2¾-in. high characters can be read at 50 ft in 50 foot-candle ambient illumination.



Giant Spin Forge Holds Precision Tolerances

Seamless rocket-engine cases are spin-forged to within 0.003 in. of basic contour by a million pounds of force. Cases 5 ft in diam and up to 10 ft long can be made without welds from flat, donut-shaped rings. Blanks 1 in. thick can be forged in a single pass into truncated cones with ½-in. wall thickness. The resulting product has a tensile strength double that of the raw material, plus superior surface finish. To control the tremendous force applied by its hydraulic rollers, the Spin Forge, developed by Hufford Corp., uses an electronic template tracing unit. Forming rolls can be operated in unison from a single template, or independently from individual templates.

NOW AVAILABLE!

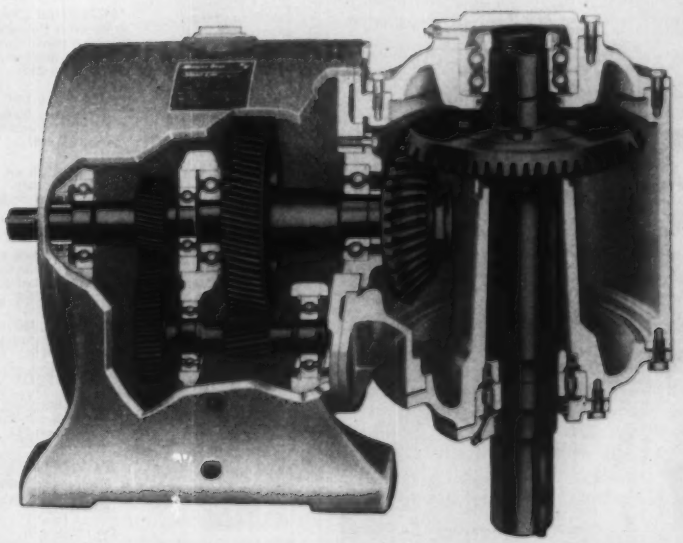


all-motor gearmotor *integral gearmotor*

Built-in customer benefits, engineered to customer needs for more than 25 years, make the Western Gear StraitLine Speed Reducers line the finest in the field. The reducer and right angle head pictured below are available in ranges from 1 HP to 75 HP, with or without motor. Let our engineers consider your needs.

WESTERN GEAR

STRAITLINE speed reducers with universal-mounted right angle head!



UNIVERSAL MOUNTING. The right angle attachment may be furnished in horizontal, vertical or intermediate positions with single or double extended shafts.

SPIRAL BEVEL GEARING. Precision cut from alloy steel forgings and case hardened for maximum strength and durability. Each set of gears is matched and lapped after hardening to insure good contact and quiet operation.

DRY WELL CONSTRUCTION. Time tested dry well construction prevents oil leakage down the output shaft for vertical applications.

OVERHUNG LOAD. Conservatively selected bearings, husky output shaft, and wide bearing span provide ample overhung load capacity for chain, pinion and belt service.

POSITIVE LUBRICATION. A simple splash lubrication system, integral with the main housing, thoroughly lubricates gears and bearings. Case design allows oil to be circulated freely at all times.

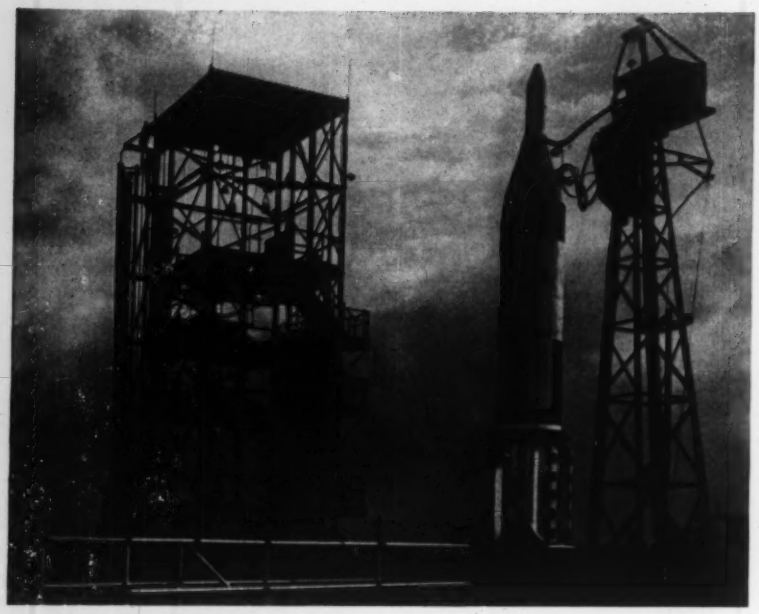
LESS MAINTENANCE. Only two alemite fittings are required to lubricate bearings when output shaft is in the vertical position. Large grease reservoirs are provided to insure positive lubrication.

WG INDUSTRIAL PRODUCTS DIVISION

WESTERN GEAR CORPORATION
Industrial Products Division
P.O. Box 126 • Belmont, California
Send me Bulletin 5816F

*name*_____
*title*_____
*company*_____
*address*_____
*city*_____ *state*_____

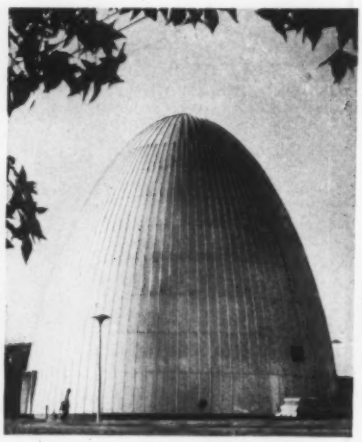
9303



Polaris: Ready in '60

Ground tests precede sea duty for the Navy's Polaris fleet ballistic missile. First photographs of the 1500-mi IRBM show the familiar landlocked gantry launching complex. At sea, Polaris will be launched underwater from the largest submarines ever built. Three of the subs, scheduled for completion in 1960, and designed to carry about 16 of the 30-ft missiles, will have displacements of 5600 tons. They will be 380 ft long and 33 ft wide at the beam. Nautilus, by comparison, displaces 3180 tons, is 320 ft long, and 30 ft at the beam.

Ten-Company Co-op Cuts Nuclear-Test Costs



PLAINSBORO, N. J.—Ten of the nation's leading industrial companies —with interests as diverse as tobacco, golf balls, and atomic batteries —have split the tab to place the world's largest swimming-pool research reactor in operation. Title of the co-operative research center, and operator of the 5-million watt reactor, is Industrial Reactor Laboratories Inc.

The ten noncompeting participants in IRL are American Machine & Foundry Co., American Tobacco Co., Atlas Powder Co., Continental Can Co., Corning Glass Works, National Distillers and Chemical Corp., National Lead Co., Radio Corporation of America, Socony Mobil Oil Co. Inc., and United States Rubber Co.

Situated on a 300-acre site near Princeton, N. J., the IRL facility is distinguished by an 87-ft high, aluminum-sheathed, concrete "beehive." The reactor itself, which generates test neutrons, gamma rays, and radioactive isotopes, resembles a 30-ft deep swimming pool. The uranium core is at the bottom of the pool, where circulating water provides shielding and removes the heat of reaction. Around the base of the pool are numerous facilities for ex-

Call Chromalox

for the man with the ELECTRICAL ANSWERS to your heating problems

ATLANTA 9, GA.
Applebee-Church, Inc.
1389 Peachtree St., N.E.
Trinity 5-7244

BALA-CYNWYD, PA.
J. V. Calhoun Company
349 Montgomery Ave.
Mohawk 4-6113
Greenwood 3-4477

BALTIMORE 18, MD.
Paul V. Renoff Company
333 East 25th St.
Hopkins 7-3280

BINGHAMTON, N. Y.
R. P. Smith Co., Inc.
94 Henry St.
Phone 4-7703

BLOOMFIELD, N. J.
R. L. Faber & Assoc., Inc.
1246 Broad St.
Edison 8-6900
New York: Worth 4-2990

BOSTON 11, MASS.
Leo C. Pelkus & Co., Inc.
683 Atlantic Ave.
Liberty 2-1941

BUFFALO 2, N. Y.
Niagara Electric Sales Co.
505 Delaware Ave.
Summer 4000

CHARLOTTE 2, N. C.
Ranson, Wallace & Co.
116½ E. Fourth St.
Edison 4-4244
Franklin 5-1044

CHATTANOOGA 1, TENN.
H. R. Miles & Associates
P. O. Box 172
Amherst 5-3862

CHICAGO 5, ILL.
Fred I. Tourtelot Company
407 S. Dearborn St.
Harrison 7-5464

CINCINNATI 8, OHIO
The Smysor Company
1046 Delta Ave.
Trinity 1-0605

CLEARWATER, FLA.
J. J. Galleher
617-A Cleveland St.
P. O. Box 1376
Phone 3-7706

CLEVELAND 13, OHIO
Anderson-Bolds, Inc.
2012 W. 25th St.
Prospect 1-7112

DALLAS 26, TEX.
L. R. Ward Company
3009 Canton St.
Riverside 1-9004

DAVENPORT, IOWA
Volco Company
215 Kahl Building
Phone: 6-5233

DENVER 2, COLO.
E. & M. Equipment Co.
2415 Fifteenth St.
Glendale 5-3651
Genesee 3-0821

DES MOINES 14, IOWA
Midwest Equipment Co. of Iowa
842 Fifth Ave.
Cherry 3-1203

DETROIT 38, MICH.
Carman Adams, Inc.
15760 James Couzens Hy.
University 3-9100

HOUSTON 3, TEX.
L. R. Ward Company
3605 Polk Ave.
Capitol 5-0356

INDIANAPOLIS 8, IND.
Couchman-Conant, Inc.
1400 N. Illinois St.
Station A, P. O. Box 88023
Melrose 5-5313

KANSAS CITY 6, MO.
Fraser D. Moore Co.
106 E. 14th St.
Victor 2-3306

LOS ANGELES 15, CAL.
Montgomery Brothers
1053 S. Olive St.
Richmond 7-9401

MIDDLETOWN, CONN.
Dittman and Greer, Inc.
33 Pleasant St.
Diamond 6-9606

MILWAUKEE 3, WIS.
Gordon Hatch Co., Inc.
531 W. Wisconsin Ave.
Broadway 1-3021

MINNEAPOLIS 4, MINN.
Volco Company
831 S. Sixth St.
Federal 6-3373

NASHVILLE 4, TENN.
H. R. Miles and Associates
2500-B Franklin Rd.
Cypress 2-7016

NEW YORK CITY, N. Y.
See "Bloomfield, N. J."

OMAHA 2, NEB.
Midwest Equipment Co.
1614 Izard St.
Atlantic 7600

PHILADELPHIA, PA.
See "Bala-Cynwyd, Pa."

PITTSBURGH 6, PA.
Woessner-McKnight Co.
1310 Highland Building
115 S. Highland Ave.
Emerson 1-2900

PORTLAND 9, ORE.
Montgomery Brothers
1632 N.W. Johnson St.
Capitol 3-4197

RICHMOND 26, VA.
O. M. Thompson
Westhampton Station
P. O. Box 8762
Atlantic 8-8758

ROCHESTER 4, N. Y.
Niagara Electric Sales Co.
133 Clinton Ave. S.
Hamilton 6-2070

ST. LOUIS 1, MO.
C. B. Fall Company
317 N. 11th St.
Suite 1001
Chestnut 1-2433

SAN FRANCISCO 3, CALIF.
Montgomery Brothers
1122 Howard St.
Underhill 1-3527

SEATTLE 4, WASH.
Montgomery Brothers
911 Western Ave.
Main 4-7297

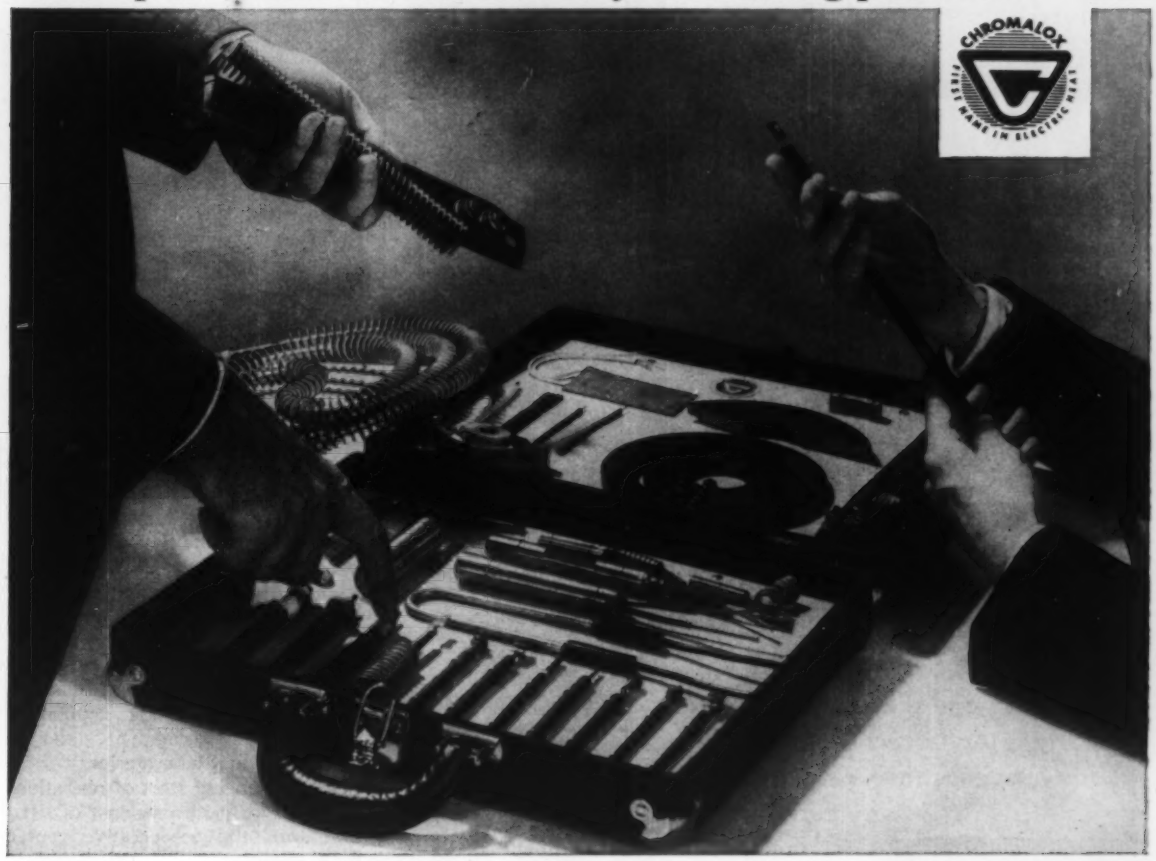
SYRACUSE 6, N. Y.
R. P. Smith Co., Inc.
2507 James St.
Howard 3-2748

WICHITA 2, KAN.
Fraser D. Moore Co.
Room 211 Derby Building
352 N. Broadway
Amherst 2-5647

CHROMALOX
Electric Heat
INDUSTRIAL · COMMERCIAL · RESIDENTIAL
EDWIN L. WIEGAND COMPANY
7575 THOMAS BLVD., PITTSBURGH 8, PA.

Circle 419 on Page 19

Want quick, correct solutions to your heating problems?



Call the Chromalox man for the **ANSWERS**

No matter what heating problem you have, there's a Chromalox electric heating unit of the type and size you need.

Your Chromalox Representative—the man with the answers to your heating problems, routine or unusual—has over 15,000 standard types, sizes and ratings to choose from and many of these are stocked in quantity for immediate use. Moreover, Chromalox has the design and manufacturing facilities to build promptly special elements to fit your special requirements, plus a complete range of controls and accessories. For instance . . .

- Strip heaters in lengths up to 96 inches, in wattages up to 1500 with temperatures up to 1200°F, as well as new heater bands designed specifically for injection and extrusion barrels.
- Chromalox Electric Tubular Heaters engineered and built to suit your design. No quick compromise with an adapted element, but a custom-designed component with the exact characteristics necessary to give years of top performance to your product.
- Specify Chromalox Electric Cartridge Heaters, and you get more dependable spot heat with close thermal control. Exclusive design gives positive lead wire protection against flexing, abrasion, moisture. Also available in new extra-high-temperature models with Inconel® sheath to provide maximum heat concentration.
- New Microfin® units for space heaters and process air in ovens and ducts provide safe, fast heating, and are workable into limitless configurations to provide maximum wattage in a given space.
- Packaged elements for Far-infrared, immersion, and circulation heating.
- Lightweight, flexible Pre-Fab woven elements—silicone-molded or laminated—for confined spaces, and areas requiring small amounts of heat.

For an on-the-spot heating analysis at no obligation, just call your Chromalox Direct Factory Representative. A call to your "man with the answers" (see listing on opposite page) will put Chromalox Service to work for you at once.

4999

CHROMALOX® Electric Heat

Edwin L. Wiegand Company

7575 Thomas Boulevard, Pittsburgh 8, Pennsylvania • CHurchill 2-6400

Now Rotary Torque Actuation, fully cushioned!

The
CARTER
ROTARY TORQUE
ACTUATOR
Patents Pending

Explore the cost reduction you can get with safe, low-cost, Carter Rotary Torque Actuators—Now with built-in cushions for longer, more dependable performance.

No by-pass leakage

Built-in cushions

Rotation to 370° as standard

Positive locking, no back-off under tension or power failure

Complete range of sizes

Proven in thousands of applications during the past 4 years!

The Carter Rotary Torque Actuator has opened unlimited new possibilities in design and cost reduction. Transfer mechanisms, indexing, positioning, cam actions, valve operation, and many other applications become more effective and economical.

Here is safe, powerful, Rotary Torque. Actuated by air, oil, water or gas. Patented seal assures leakproof performance. Internal helical design prevents back-off under reverse tension, shock, vibration or complete power failure.

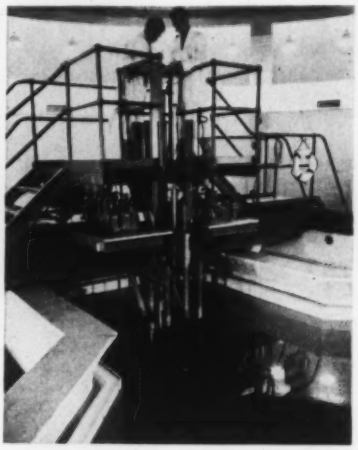
Available in 4, 5, 6, 8, 10 and 12" diameters. Special sizes and rotation requirements are available. Ask your Carter representative or write for all the details!

Complete power package units available

SEND FOR NEW BULLETIN

Bulletin R.A. 500 gives complete details and specifications on the Carter Rotary Torque Actuators. Every engineer and designer should have a copy. Send for yours today!

CARTER
CONTROLS, INCORPORATED
2914 Bernice Road, Lansing, Ill.
Phones: Lansing—GRanite 4-3305•Chicago—RAyport 1-7188



perimental work, including special chambers in which materials under test are inserted for exposure to various types and levels of radiation. Adjoining hot cells, equipped with mechanical manipulators, allow examination of test specimens.

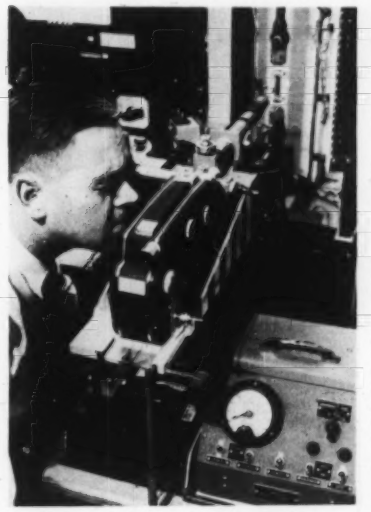
The permanent operating staff of the reactor will total from 30 to 40 scientists and technicians. In addition, the participating companies will maintain permanent staffs in their individual laboratories.

In announcing start of operation, Harry L. Hilyard, president of IRL, said that the co-operative center "sets a pattern which all of industry may ultimately follow in order to make use of the most advanced techniques." He pointed out that the ten noncompeting companies now have at their disposal a complete nuclear facility at a fraction of what it would cost on a single-company basis.

Vacuum Coating Beats Hydrogen Problem

NEWTON, MASS.—Cadmium vapors condensed on high-strength steel in a vacuum can make a dense, nonporous coat without danger of hydrogen embrittlement. A low-cost process produces a 0.001-in. thick coating, using existing vacuum-coating machines developed by NRC Equipment Corp., Newton, Mass. Military specs usually rule out cadminum electroplating because of history of hydrogen embrittlement. But MIL-C-8837 (ASG) permits the process for Air Force and Navy parts.

Circle 421 on Page 19



Camera Monitors Creep Strain

Extremely accurate recordings of high-temperature creep-strain tests are made with a 16-mm camera at the Martin Co. Furnace (upper right) is swung aside to disclose test specimen, to which a small, slide-rule type platinum gage has been clamped. Specimen and gage are magnified by a microscope, with the image passing to both camera and optical viewer by way of a reflex. Time, stress, and temperature information are fed into the film record by an imposition device. The solenoid-timer (lower right) can be set for readings at any interval between 64 frames per sec and 1 frame every 10 hr. A battery of cameras, linked to a single timer, is used to make synchronized records.

5000 F Doesn't Crack New Ductile Ceramic

WILMINGTON, MASS. — A 5000-F blast of rocket-engine exhaust has little damaging effect on a new reinforced ceramic developed by Avco Research and Development Div. According to Avco, the new material resists gas erosion at extreme temperatures and eliminates structural failure due to heat shock. Called Avcoite, the ceramic is being used in the fabrication of rocket nozzles, nozzle components, and in other high-temperature applications.

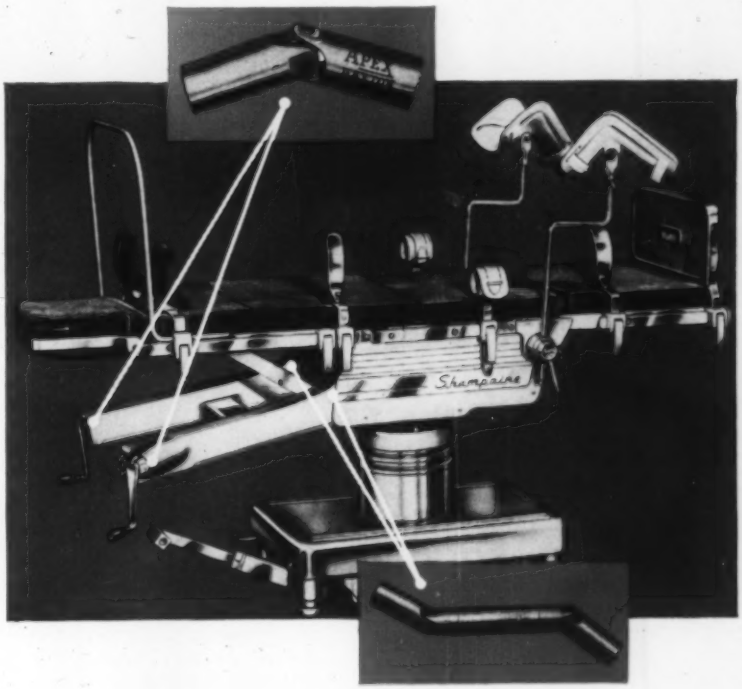
Although the nature and method of manufacture of the new material are not disclosed, Avco's research group revealed that a normally

(*Please turn to Page 40*)

APEX SPECIAL universal joints

The completely new design concept evident in the Shampaine Surg-a-matic major operating table includes four Apex universal joints, each specially designed for a specific application. These joints are components in the push-button controlled mechanism that provides the many intricate and accurate table positionings required by modern surgical techniques.

Two Apex single universal joints are mounted on fixed shafts, serving as universal joints and as extreme angle couplings, and operate freely at a constant 30° angle. Two Apex double universal joints operate at maximum angles of 15° and 27°. All four joints are cadmium plated.



APEX STANDARD universal joints

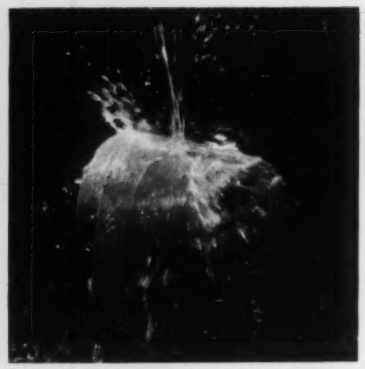
In addition to "specials," Apex offers a full range of standard universal joints, 3/8" to 4" diameter, including the exclusive Apex covered universal joint for service in fluids, gases, corrosive atmospheres or in extremes of heat or cold. Write, on your company letterhead please, for Catalog 28.

THE APEX MACHINE & TOOL CO.
1042 South Patterson Blvd.
DAYTON 2, OHIO

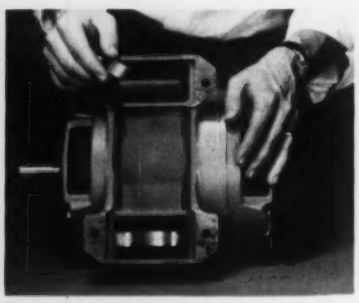
Phantom view of APEX covered universal joint which operates efficiently in wet or dry, corrosive or abrasive atmospheres, and in extremes of temperature.

Circle 422 on Page 19 Circle 423 on Page 19→

Get faster assembly–more dependable

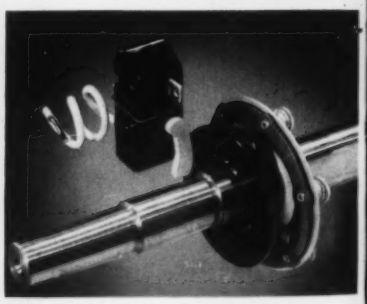


Better Protected against dripping or splashing liquids, this G-E motor is suitable for many jobs where an ordinary dripproof motor cannot be applied.



Base-mounted Capacitors eliminate bulky capacitor "top hat," are safe from physical damage. Easy-to-remove spring clips hold capacitors in place.

Perma-Numbered Leads are always easy to identify. Non-wicking neoprene insulation prevents moisture from running up leads into vital parts.



Totally-enclosed Transfer Switch assures positive contact and long life—over 1,000,000 consecutive operations on test.

operation for your products . . .

WITH GENERAL ELECTRIC TRI 55 CLAD SINGLE-PHASE MOTORS

HERE'S WHY:

Perma-numbered leads in the G-E Tri/Clad '55' motors make connection easier because they are easy to identify. Threaded conduit entrance eliminates need for internal lock nut . . . faster installation results. And rigid cast-iron frame and endshields prevent motors from being twisted out of line during assembly operations—make machine operation more dependable.

THE SMALL SIZE AND LIGHT WEIGHT of Tri/Clad '55' standard motors facilitates installation on your products; helps reduce mounting and shipping costs *without* sacrificing full-power performance. Also, G.E.'s dripproof design allows these single-phase motors to be used for many applications which normally require splashproof type motors . . . you save money.

FOR LONGER MOTOR LIFE, G-E Tri/Clad '55' motors feature Mylar* polyester film insulation, Formex† magnet wire, water-resistant stator coating, and better physical protection. Longer motor life, of course, results in longer life and increased dependability for your products.

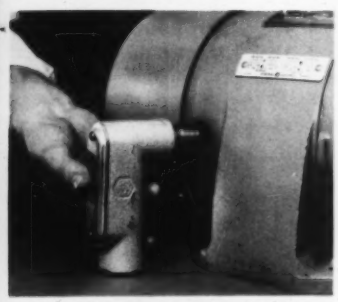
COMPARE G-E Tri/Clad '55' motors with other makes of motors. Remember: (1) General Electric offers you a complete line of single-phase motors to choose from . . . dripproof or enclosed, vertical or horizontal, C-face or D-flange, all of which meet NEMA standards. (2) You'll also be pleased with the ***exceptionally*** fast delivery you can get and with G.E.'s small motor service station plan . . . a real plus in cementing customer relations.

CONTACT your local G-E Apparatus Sales Office now for personal proof of how these G-E motors can help cut your costs, reduce assembly time, and give longer-life operation. And ask for your free copy of illustrated bulletin GEA-6240, or write Section 840-18, General Electric Company, Schenectady 5, New York.

*Registered Trade-mark of DuPont Co.

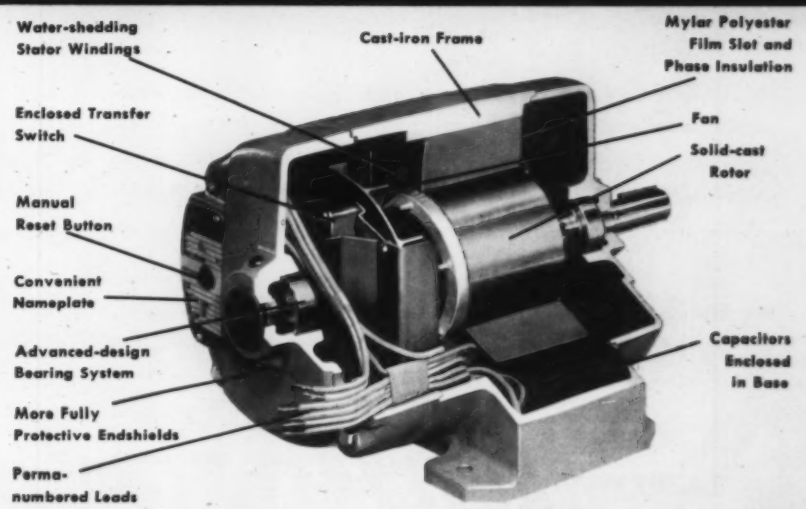
†Registered Trade-mark of General Electric Co.

GENERAL ELECTRIC



Threaded Conduit Entrance permits quick, easy installation; provides tighter, dust-proof seal for conduit.

SINGLE-PHASE TRI CLAD MOTORS OFFER THESE TIME AND MONEY SAVING FEATURES



Standard single-phase Tri/Clad '55' motor

A story without an ending!

The Versatility of TAYLOR Vulcanized Fibre

What this material is . . .

Vulcanized fibre is truly one of the wonder materials of all times. It is hard and dense, with excellent physical, mechanical and electrical properties. It is tough and resilient—has high resistance to impact, abrasion, wear, organic solvents, oils and gasoline. It is attractive and light in weight.

What can be done with it . . .

Vulcanized fibre can be machined, turned, stamped and punched. It can be formed, sawed, drilled, planed, milled and chiseled. It can be hammered, shaved, threaded, buffed and sanded. It can be decorated by lacquering, painting, printing and engraving. It can be laminated.

How it can be used . . .

Vulcanized fibre can be used for welders' helmets, golf club face inserts, carrying cases, track and motor insulation, and abrasive discs. It can be used for switch parts, gears, sliding door guides, shuttles, bobbin heads, labels and tags; for facings, table tops, partitions and kitchen utensils. There is no end to the things that can be done with it and the applications for which it is suited.

For more complete information on the forms and grades available, contact TAYLOR FIBRE CO., Norristown 47, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

(*Continued from Page 37*)

brittle ceramic has been developed to be quasi ductile. Excessive stresses cause deformation rather than fracture. In tests on full-scale rocket motors, Avcoite nozzle throats have shown little structural change at temperatures of 5000 F for test durations of 60 sec.

Hard Magnets Stay Attractive After Bath in Hot Radiation

Most Permanent Materials Pass Navy's Nuclear Test

WASHINGTON — Permanent magnets can endure the "hot" atomic ordeal without measurable change in their magnetic properties.

This was recently demonstrated by scientists at Naval Ordnance Lab in the first comprehensive study in the U. S. on irradiation of permanent magnetic materials.

Unlike soft magnetic materials, some of which show drastic degradation under radiation, the permanent magnets showed no measurable changes following exposure in the Brookhaven National Laboratory reactor—they met or exceeded radiation environmental requirements established by the Defense Department for electronics equipment designed for nuclear-powered aircraft and ballistic missiles.

In conducting the tests . . .

samples were irradiated in the Brookhaven reactor for 12 days, at a fast flux rate of 10^{11} neutrons per sq cm per sec, or higher, corresponding to an integrated fast flux of 10^{17} neutrons per sq cm. Temperature in the pile hole was 90 C. Unirradiated control samples were also held at 90 C in an oven for 12 days. Demagnetization curves and inductions at open magnetic circuit were measured before and after irradiation.

Materials tested by NOL included: 3½ chromium-steel; 36 cobalt-steel; Alnico II, V, and XII; Cunico; Silmanal; fine irons; platinum-cobalt; unoriented barium-ferrite, and oriented barium ferrite.

Test results . . .

indicated that most commercially available hard magnetic materials can be used, with little or no modi-

Circle 424 on Page 19

fication, in currently designed nuclear aircraft and missiles. This contrasts sharply with the findings on radiation effects upon soft magnetic materials, most of which could not function in a nuclear environment for any significant length of time.

But trouble ahead . . .

is predicted by NOL physicists. They expect that as the amount of integrated neutron flux is increased to the order of 10^{19} or 10^{20}, the magnetic properties of permanent magnets will also deteriorate. When this degradation point is reached in the course of missile and space-vehicle development, breakthroughs will be needed.

One fact appears inescapable to the scientists—the overall environment, nuclear and otherwise, to which modern war weapons are subjected is so severe that electronic equipment built with currently available materials and parts cannot be expected to reach a level of absolute reliability. This is especially true in the case of missiles, where electronic equipment is an integral part of the vehicle and cannot be separated from the powerplant.

Meetings

AND EXPOSITIONS

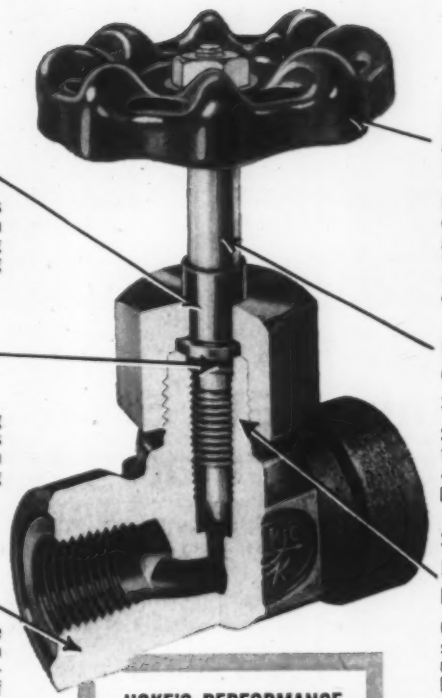
March 2—

Cleveland Engineering Society. Sixteenth Annual Design Conference, sponsored by the Machine Design Div. of the society, to be held at the Cleveland Engineering and Scientific Center. Additional information can be obtained from S. N. Schlein, c/o Cleveland Engineering and Scientific Center, 3100 Chester Ave., Cleveland 14, Ohio.

March 8-11—

American Society of Mechanical Engineers. Gas Turbine Power Conference and Exhibit to be held at the Netherlands-Hilton Hotel, Cincinnati, Ohio. Further information can be obtained from ASME headquarters, 29 W. 39th St., New

LOW COST FLUID CONTROL at HIGH PRESSURES (and low, too)



EXCLUSIVE NYLON STEM WIPER
Positively prevents foreign matter from scratching or pitting stem, harming O-ring seal.

GUARANTEED LEAK-PROOF O-RING SEAL
Forget about packing adjustments, leaks through stem with tough, pliable O-ring seal.

FORGED CARBON STEEL BODY
Heavy duty, weldable carbon steel body in globe or angle patterns, selection of male or female connections.

DIE-CAST ALUMINUM HANDWHEEL
Easy grip, non-slip, die-cast handwheel gives you smooth turning down for quick, accurate flow control.

CENTERLESS GROUND STEM
Stainless steel, centerless ground stem assures perfect fit, positive shut-off.

SAFE, INTEGRAL BONNET
One-piece, forged steel body and bonnet insures against blow-out, gives added measure of safety.

HOKE'S PERFORMANCE GUARANTEE—
Every Valve Leak-Tested!

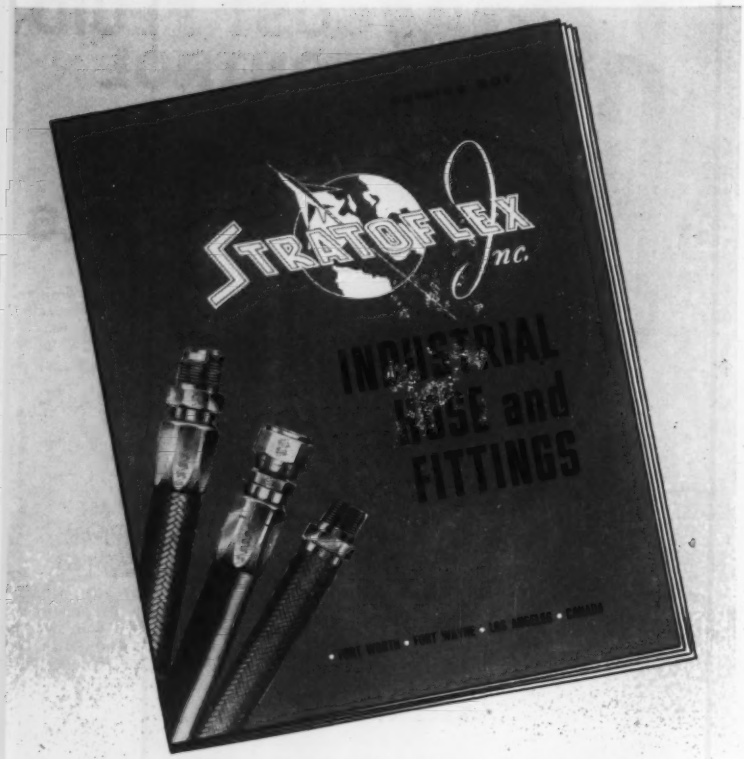
SERIES 100 FORGED NEEDLE VALVES

FREE: A sample valve is yours for the asking. Put this heavy duty, versatile valve to the test on hydraulic lines, manifolds, air lines, test stands. Use it for regulating or shut-off of water, oil, gas. Temperature range –40 to 200°F. Pressure rating; vacuum to 10,000 psi. Write to us on your company letterhead for the full story and your FREE SAMPLE VALVE.

HOKE

HOKE INCORPORATED
Fluid Control Specialists
91 PIERMONT RD., CRESSKILL, N. J.

Circle 425 on Page 19



Get this NEW Stratoflex Industrial Catalog NOW!

- Contains complete information for specifying single and double wire and fabric braid hose along with Stratoflex industrial fittings.
- Includes a section on special application hose and shows Stratoflex equipment for field assembly of hose and fittings for fluid lines.
- Comprehensive Hose Selector Charts are included, along with easy-to-read diagrams illustrating the proper installation of flexible hose.
- All-new technical data section contains helpful Industrial Weight Charts and a Thread and Decimal Equivalent Chart.

Mail Coupon Below for Your Free Copy Today!

STRATOFLEX Inc.

P.O. Box 10398 • Fort Worth, Texas
Branch Plants: Los Angeles, Fort Wayne, Toronto
In Canada: Stratoflex of Canada, Inc.

SALES OFFICES: Atlanta, Chicago, Cleveland, Detroit, Fort Wayne, Fort Worth, Houston, Kansas City, Los Angeles, New York, Philadelphia, Pittsburgh, San Francisco, Seattle, Toronto, Tulsa

SF2-9

Stratoflex, Inc. MD
P. O. Box 10398, Fort Worth 14, Texas
Please send me your new 64-page Industrial Catalog:
Name_____ Title_____
Firm_____
Address_____
City_____ Zone_____ State_____

York 18, N. Y.

March 8-12—

American Society of Mechanical Engineers. Aviation Conference to be held at the Statler-Hilton Hotel, Los Angeles. Additional information is available from society headquarters, 29 W. 39th St., New York 18, N. Y.

March 9-10—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 11-13—

Pressed Metal Institute. Spring Technical Meeting to be held at the Pick-Congress Hotel, Chicago. Further information can be obtained from PMI headquarters, 3673 Lee Rd., Cleveland 20, Ohio.

March 16-17—

American Society of Mechanical Engineers. Lubrication Conference to be held at the Franklin Institute, Philadelphia. Further information is available from ASME, 29 W. 39th St., New York 18, N. Y.

March 16-18—

Society of Automotive Engineers Inc. National Passenger Car, Body, and Materials Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 16-20—

Eleventh Western Metal Exposition and Congress to be held at the Pan-Pacific Auditorium and the Ambassador Hotel, Los Angeles. Sponsors are the American Society for Metals and other technical groups. Further information is available from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

March 19-20—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Further information is available from society headquar-

Circle 426 on Page 19

ters, 485 Lexington Ave., New York 17, N. Y.

March 31-April 2—

21st American Power Conference to be held at the Hotel Sherman, Chicago. Conference is sponsored by Illinois Institute of Technology, in co-operation with 9 technical societies and 13 other educational institutions. Additional information can be obtained from R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

March 31-April 3—

Society of Automotive Engineers Inc. National Aeronautic Meeting, Aeronautic Production Forum, and Aircraft Engineering Display to be held at Hotel Commodore, New York. Additional information is available from SAE, 485 Lexington Ave., New York 17, N. Y.

April 5-10—

Nuclear Congress to be held at the Public Auditorium, Cleveland. Additional information can be obtained from Engineers Joint Council, 29 W. 39th St., New York 18, N. Y.

April 6-10—

American Welding Society. Annual Welding Show and Convention to be held in Chicago. Technical meetings will be at the Hotel Sherman Monday through Friday; the show will be at the International Amphitheatre Tuesday through Thursday. Further information is available from society headquarters, 33 W. 39th St., New York 18, N. Y.

April 13-17—

American Foundrymen's Society. Castings Congress and Engineered Castings Show to be held at Hotels Sherman and Morrison, Chicago. Additional information can be obtained from AFS, Golf and Wolf Roads, Des Plaines, Ill.

April 18-22—

American Society of Tool Engineers. Annual Meeting to be held at the Schroeder Hotel, Milwaukee. Further information can be obtained from society headquarters, 19700 Puritan Ave., Detroit 38, Mich.

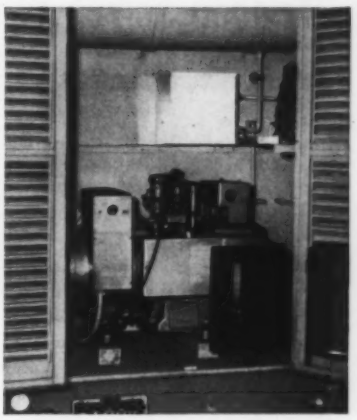
Onan NEWS REPORT

How to provide electric power for ice cream stores that move!

Mister Softee mobile ice cream vans are as fully electrified as a store with utility connections. Ice Cream freezers, air conditioner, lights, fans . . . even the heater that keeps "Hot Fudge" hot are operated by electric power.

The Onan 10KW electric plant supplies all current required with a generous reserve for future electrical loads. It is mounted at the rear of the truck in an easily accessible compartment. Onan's Vacu-Flo cooling keeps the compartment ventilated . . . delivers all heated air to the outside. Over 300 of these Mister Softee vans are now in operation.

Where you need electric power on mobile units . . . an Onan electric plant will provide service with dependability approaching that of the electric utility. 500 to 200,000-watt models. Gasoline or Diesel.



Onan 10KW, CW Series plant shows simple, accessible installation. Two-cylinder, gasoline engine is smooth-running and quiet.

Need specific information for your particular job?

Call the Onan distributor listed in your phone book or write direct.

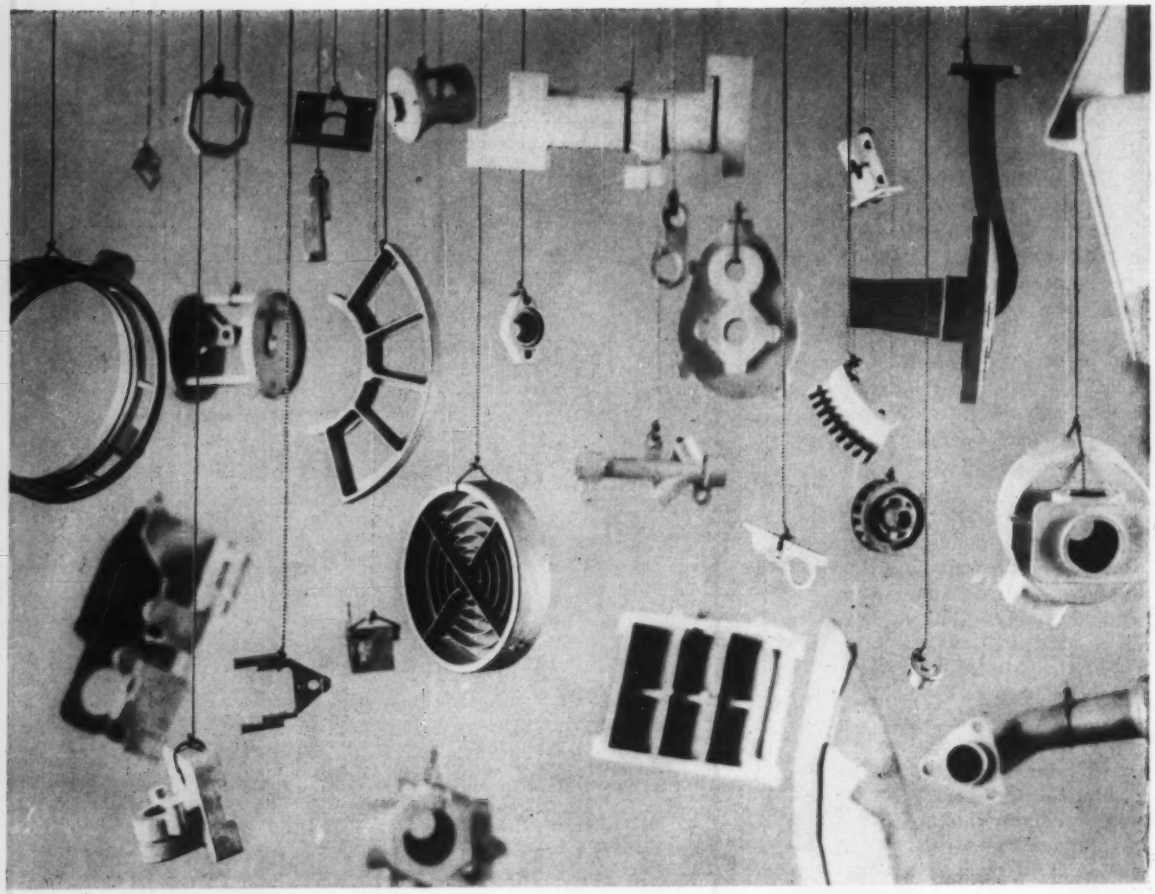
D. W. ONAN & SONS INC.

3011 University Ave. S.E., Minneapolis 14, Minnesota

ELECTRIC PLANTS • AIR-COOLED ENGINES • KAB KOOLER • GENERATORS

Onan ELECTRIC PLANTS

Circle 427 on Page 19



This assortment of castings represents about half the number of new parts that go into production at Arwood's four plants in a typical week.

Arwood solves twice this many design problems each week!

Could Investment Casting help you?...a prompt answer is yours for the asking

Upon receipt of a drawing or sample of your part, Arwood will give you a prompt, honest appraisal, spelling out exactly what we propose to furnish. We will also suggest minor design changes that may save you money without affecting the part's performance.

Arwood can handle the complete job, from design and tooling through to finish machining, in any castable metal or alloy. Arwood assumes complete responsibility . . . your procurement problems are at an end.

Arwood's four fully-equipped production plants and well-staffed tool rooms are geared to give fast service. Each job is individually scheduled to assure you of delivery of finished castings in the shortest time possible.

Large and small companies come to Arwood for quotations at the rate of fifty a day . . . without obligation. Why not let us help *you* evaluate the potential savings you may realize by making your part an Arwood investment casting?

Write today for your free copy of the new 44-page Arwood Manual of Investment Casting. Provides all the information you need to evaluate the technique and use it to help solve your design problems.

arwood

ARWOOD PRECISION CASTING CORP.
315 West 44th Street, New York 36, New York

A complete service from design through tooling, production and finish machining. Sixty-two engineering consultants from coast to coast.

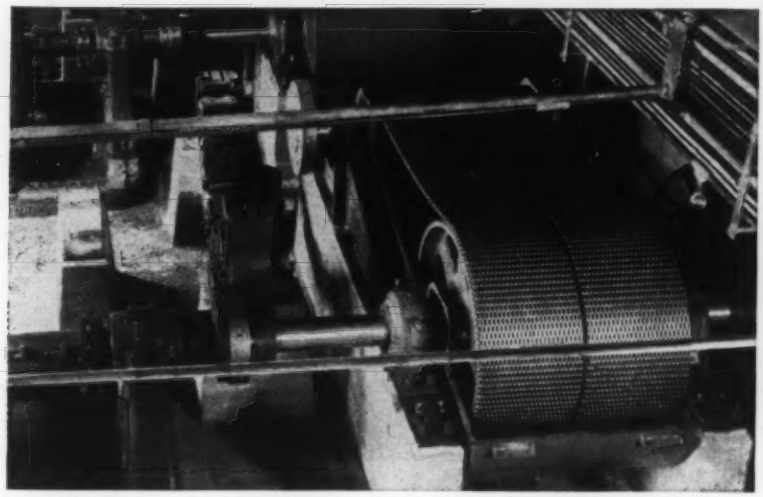
PLANTS IN BROOKLYN, N. Y.; GROTON, CONN.; TILTON, N. H. & LOS ANGELES, CALIF.

Circle 428 on Page 19

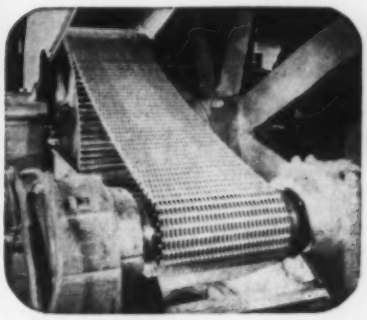
How LINK-BELT silent chain comes through industry's stiffest tests

No other drive can do the same

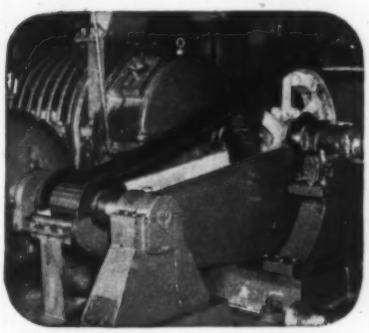
HIGH SPEED. Link-Belt silent chain drives on newspaper presses often operate at speeds of 4000 to 5000 feet per minute.



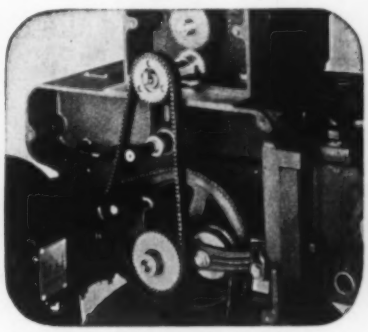
LARGE OR SMALL HP. Two 24-in. strands of Link-Belt silent chain on turbines powering 850-kw generators comprise one of the largest chain drives ever built. Silent chain provides high efficiency (over 98%) on large or fractional hp drives.



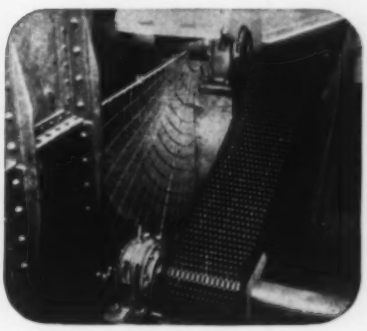
ADVERSE OPERATING CONDITIONS. Effects of heat, humidity and cold are minimized with Link-Belt silent chain drives.



LARGE RATIOS. Link-Belt silent chain operates efficiently at ratios as high as 10-to-1, with resulting space economies.



COMPACTNESS. A complete drive as small as your thumb—Link-Belt 3/16-in. silent chain is ideal for limited-space applications.



LONG LIFE. Link-Belt silent chain has given more than 30 years of uninterrupted service on ventilating systems.

Get in touch with your nearest Link-Belt office for

88-page Data Book No. 2425

LINK-BELT

SILVERSTREAK SILENT CHAIN DRIVES

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 14.680-A

STEEL LINES FOLD LIKE AN ACCORDION
Typical of diverse swivel joint applications, newly designed Chiksan Discpak joints are installed on the steam lines of a platen press. This new type swivel joint, designed for hot gas and steam, allows inexpensive packing replacement without removing swivel joint from line.

WHEN *design*
DICTATES
METAL LINES . . .

SOLVE LINE FLEXING PROBLEMS

with **CHIKSAN** SWIVEL

Chiksan swivel joints allow metal lines to be flexed in predetermined travel arcs, eliminate hose rupture, reduce maintenance and replacement costs.

Where tight bends in pressure hose make wide loops necessary, Chiksan swivel joints, conversely, permit compact placement of lines. When used with hose, Chiksan swivel joints shorten hose lengths and also lengthen hose life by minimizing tight bend and torsional fatigue.

Chiksan swivel joints are available from stock in a wide range of materials, temperatures, and pressures to meet practically every design requirement. Chiksan swivel joint packing units are designed for specific services. For example, packings have been developed to efficiently handle non-inflammable hydraulic fluids. Write today for catalog and name of nearby sales engineer.

LONG SERVICE LIFE ➤ Chiksan swivel joints deliver years of service with only occasional maintenance attention. All-steel hydraulic lines on Flash-Butt welder, shown at right, allow lines to shift as machine is adjusted to handle various work.

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

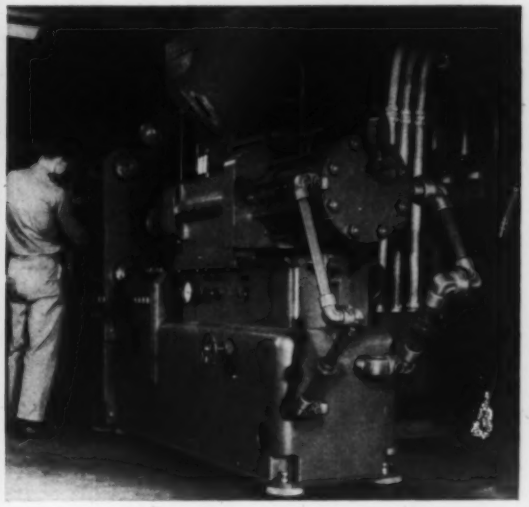
CHIKSAN

CHIKSAN COMPANY–BREA, CALIFORNIA • CHICAGO 5, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Subsidiaries Chiksan Export Company • Chiksan of Canada Ltd

NO HOSE BURST DANGER HERE...

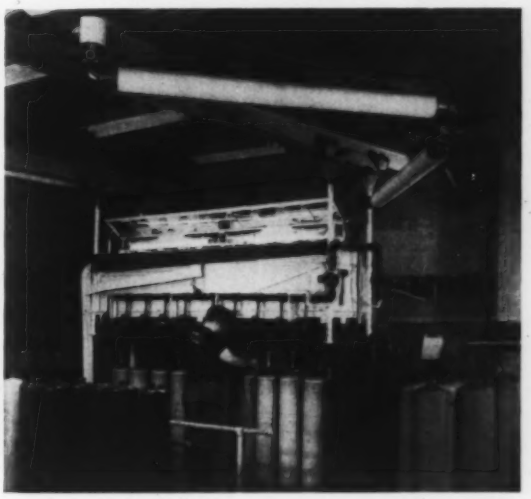
Critical lines take on a new measure of safety with all-steel flexible units replacing pressure hose. These all-metal swivel jointed lines shown on a die casting machine above, eliminate damaging hose ruptures, and reduce fire hazard, fluid loss and setup time by 75%.

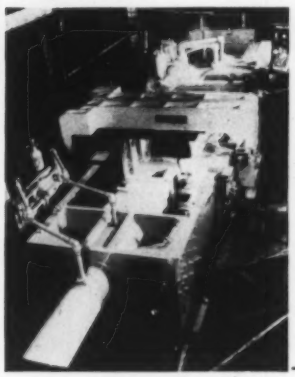


PRESSURE? TEMPERATURE? CHIKSAN MEETS THE NEED...

Over 2,000 different types, styles and sizes in a variety of temperature and pressure ratings are available to meet your design needs. This plastic injection molding machine, above, uses two different sizes of Chiksan swivel joints on its hydraulic lines.

JOINTS





NO LIMIT ON LINE DESIGN

Free swiveling action in 1, 2 and 3 planes permits design of compact lines to meet any requirement. This overhead line in service at a water softener regenerating plant permits shift from one setup of tanks to another for faster handling of tank regeneration.

#58-31

CHIKSAN COMPANY
330 NORTH POMONA AVENUE, BREA, CALIFORNIA

Please send me copy of your latest catalog

Name_____ Company_____

Title_____ Address_____

City_____ Zone_____ State_____

You're in for a Hot Time

but Fenwal's New Miniature

Hermetically Sealed THERMOSWITCH® Unit will control it—precisely!

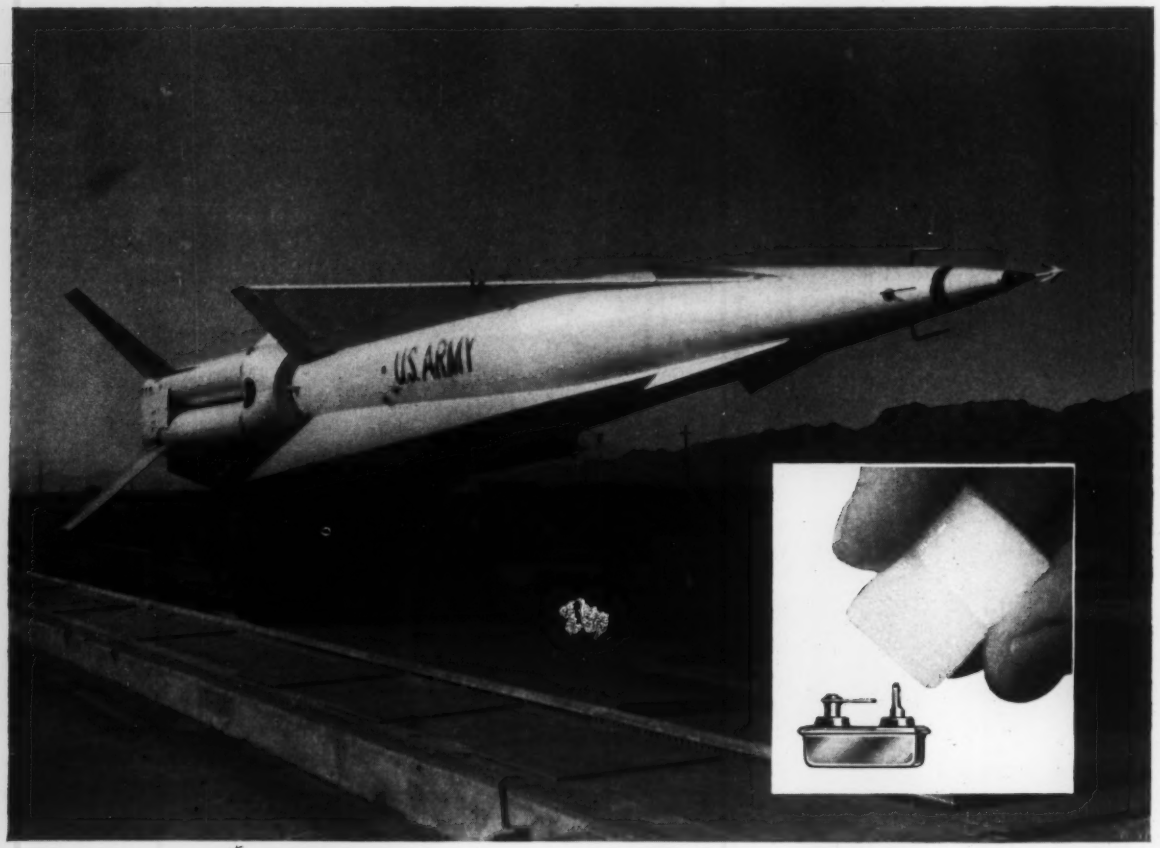
There'll be a hot time in the old ionosphere tonight. But with Fenwal's new Miniature Hermetically Sealed THERMOSWITCH Unit aboard everything will be under control. This tiny Fenwal unit responds quickly and accurately to temperature changes — *it's reliable!*

It's hermetically sealed, yet field adjustable. Even extreme vibration and shock won't upset its control characteristics — *it's built to take it!*

But most of all, this corrosion-resistant Fenwal unit does it all with exacting control of within 1° — in temperatures of −20°F to +200°F (−65°F to +220°F exposure limits). And it's the only unit that has all three features — *small size, ruggedness and precision control!*

If missiles are your business you'll want all the information on this tiny, tough, sensitive and reliable control. For more information on this unit or complete Fenwal temperature control systems, write for our catalog. If you want, we'll send our sales engineer, too. Fenwal Incorporated, 192 Pleasant Street, Ashland, Massachusetts.

The new Fenwal Miniature THERMOSWITCH Unit (compared here with a lump of sugar) weighs less than ¼ oz. Its current capacity is 2.5 amps, 115 VAC, 2.0 amps, 28 VDC. Widely used for crystal ovens, tuning forks, gyro assemblies, missile blankets and missile batteries.



ANOTHER EXAMPLE OF HOW **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

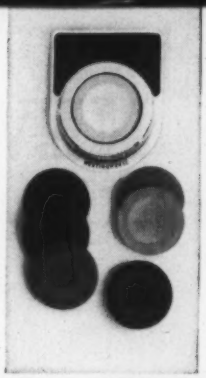
Circle 431 on Page 19

NEW *from* SEALMASTER®

SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 18 RIDGEWAY AVE., AURORA, ILLINOIS

So what's new about a flush pushbutton? **This!** . . . new Westinghouse flush pushbuttons are the *thinnest overall!* The new button is thin . . . the new contact blocks are shallow . . . the entire flush pushbutton is the *thinnest* from front to back! What's more, you can stack these new, shallow blocks for control of multiple operations. **And this!** . . . only Westinghouse flush pushbuttons have a variety of color-coded snap-on caps that let you change the color of the button *without changing the button!* New Westinghouse flush pushbuttons are oiltite, of course . . . they were designed by Westinghouse, with the cooperation of representatives of the machine tool industry, to meet the most exacting requirements of machine tool and control panel applications.

And, they're available *now* from the manufacturer of the world's most complete line of pushbuttons. To order, simply contact your nearby Westinghouse sales office or distributor, or write: Westinghouse Electric Corp., Standard Control Division, Beaver, Pennsylvania.

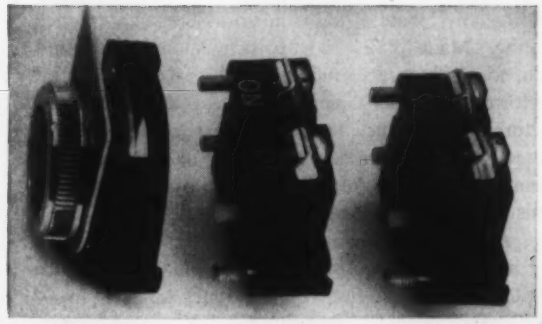


Change the color without changing the button! Color-coded snap-on caps come in red, black, blue, green, gray, yellow, brown.

YOU CAN BE SURE...IF IT'S **Westinghouse**

WATCH "WESTINGHOUSE LUCILLE BALL-DESI ARNAZ SHOWS" CBS TV MONDAYS

ANNOUNCING the newest addition to



New shallow contact blocks can be easily stacked to give you multiple control circuits. Terminals are angled... easy to get at with a screwdriver, even when blocks are stacked.

Industry's most complete line of pushbuttons

FLUSH PUSH-BUTTONS

Circle 433 on Page 19

Extruded closed cell neoprene sponge makes better appliance gaskets

Gasketing material of closed cell neoprene sponge is helping solve some of the major problems in appliance sealing. Made of a non-absorbent sponge body and thin, tough neoprene outer skin, this sealing material performs well under the most severe conditions. Manufacturers' acceptance tests show that it can take hot water, detergents, cooking oils and food chemicals without harm. This gasketing material also has excellent resistance to abrasion, ozone and natural aging. If you design or manufacture an appliance or assembly involving a compressible seal, you will want more details. Write to E. I. du Pont de Nemours & Co. (Inc.), Elastomer Chemicals Department (MD-2). Wilmington 98, Delaware.

Above—Acceptance tests on neoprene sponge were run for 100 hours in water at 212°F., food fats and detergents at 180°F. Results showed less than 10% swell, low water absorption, no damage to sealing properties.

Upper left—Tough neoprene skin on extruded gasket resists abrasion, ozone, natural aging—won't chip, crack or peel. Closed cell neoprene sponge retains its compressibility and sealing pressure.

Left—Neoprene sponge gasket can be bent around sharp radii without wrinkling. Sharp corners can be cut and cemented; closed cell sponge structure is non-absorbent.

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

SYNTHETIC RUBBER

NEOPRENE
HYPALON®
VITON*
ADIPRENE®

*Trademark for Du Pont Synthetic Rubber

Circle 434 on Page 19

whatever the size... the type... the use...

YOU'LL FIND BCA BALL BEARINGS RIGHT FOR THE JOB!

For more than half a century BCA has been a primary supplier of ball bearings for original equipment to most of the leading manufacturers of passenger and commercial vehicles, tractors and farm implements.

Customers tell us that our engineering cooperation has enabled them to effect production economies and improve product performance.

Over the years BCA has demonstrated production flexibility that assures prompt, as-promised delivery of emergency as well as routine requirements . . . in sample or production quantities.

BCA welcomes the opportunity to discuss with you any of your ball bearing applications or problems.

BCA

BEARINGS COMPANY OF AMERICA

NEW: ***Man-made Giraffe***

Unique Aerial Platform Moves On Cylinders Made From Pittsburgh Tubes

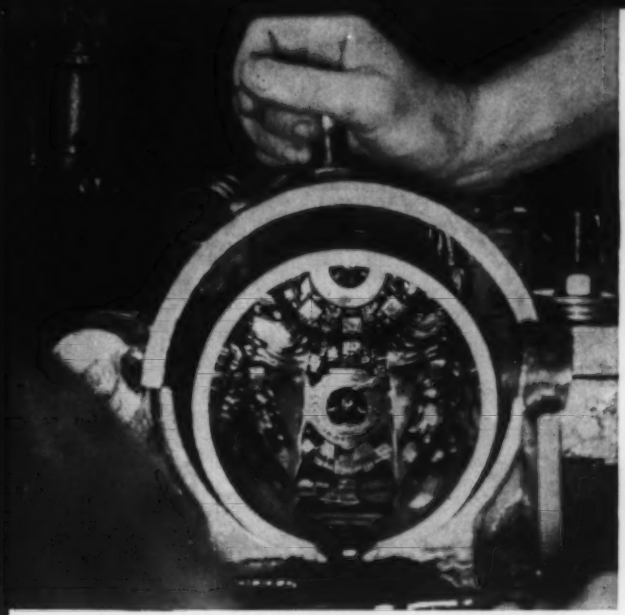
Giraffes are big business at Pitman Manufacturing Company.

Not the giraffes of the animal kingdom but ingenious hydraulic aerial platforms. These mechanical "Giraffes" are used for anything from de-icing a giant Air Force bomber to fighting fires in tall buildings.

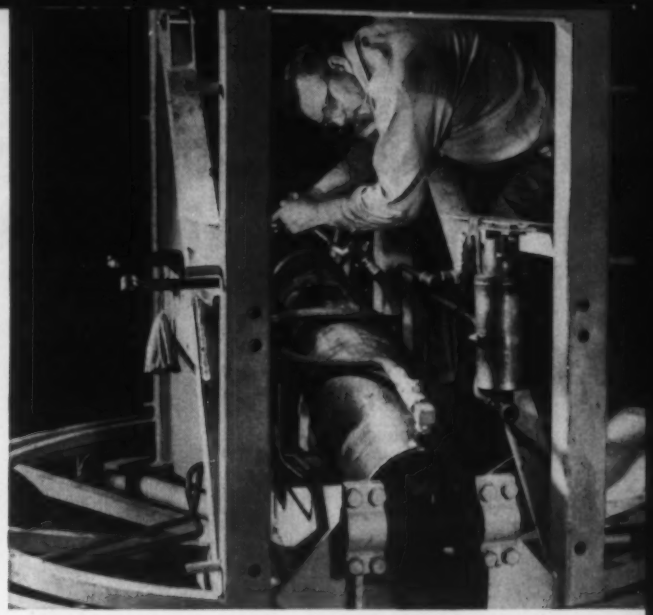
Pitman's truck-mounted Giraffes depend on hydraulic cylinders made exclusively of Pittsburgh Steel Company's seamless mechanical tubes. Giraffes are finding wide acceptance in varied industries because:

- Workmen can reach heights up to 65 feet in a fraction of the time and cost required by other methods. And their tools go up right with them.
- The roomy, insulated platform carries two men who can control all platform movements with controls duplicating those on the ground.
- The aerial platform can rotate a full 360 degrees in either direction in a radius as great as 35 feet.
- The largest of three models permits the 31-foot upper boom to move in a 160-degree vertical arc. The 23-foot lower boom can move in an 80-degree arc, so workmen can reach the exact spot they want.
- Hydraulic outriggers, operated independently, are raised or lowered by moving hand levers at side of truck.

Since hydraulic cylinders are vital to safe, dependable, economic operation of the Giraffe, Pitman makes its own cylinders with great care.



Horizontal honing of Pittsburgh Steel tubes is an exacting process. Inside the tube, you can see part of the hones. At the end of the tube, the hones are mirrored on polished steel.



Finished cylinder is installed on turntable of Pitman Giraffe. This cylinder supports and moves the lower boom. Completed Giraffe will be mounted on truck supplied by customer.

All Giraffe hydraulic cylinders are made from tubing produced by the Tube Mills of Pittsburgh Steel Company and sold by the Kansas City distributor, Metal Goods Corporation.

"We get high production from tubes because Pittsburgh tubes hold to close tolerances," declared Arthur Moore, vice president and general manager of Pitman Manufacturing. He added:

"We give Pittsburgh Steel tubes credit for cutting our scrap losses. But economy isn't all we're thinking of. Since we never forget that men's lives depend on our cylinders we build a safety factor of at least three into every cylinder. We've never had a burst cylinder or a cylinder wall failure with Pittsburgh tubes.

"Finally, Pittsburgh Steel gives us the kind of service we like."

Mr. Moore said engineers from Pittsburgh Steel helped analyze the company's tube problems, suggested some design changes and took Pitman's prints back to the mill to make tubing which exactly fills the bill.

"The service which Pittsburgh Steel instituted ended our tubing problems," said Mr. Moore. "Our cylinders have been very satisfactory ever since."

Whether you make hydraulic cylinders or use seamless mechanical tubing in another application needing uniformity, close tolerances and engineering help, you can profit by Pitman's experience.

Start today by getting in touch with trained help available through any Pittsburgh Steel Company District Office or from one of the Pittsburgh Steel distributors listed at right.

Fire-fighting is just one of many uses for the Pitman Giraffe. These fire-fighters can move their platform to any given spot quickly and easily without losing time when time counts most.

Pittsburgh Seamless Distributors

Baker Steel & Tube Company
Los Angeles, California

Chicago Tube & Iron Company
Chicago, Illinois

Cleveland Tool & Supply Co.
Cleveland, Ohio

Drummond McCall & Co., Ltd.
Montreal, Quebec, Canada

Edgcomb Steel Company
Philadelphia, Pennsylvania

Gilmore Steel & Supply Co.
San Francisco, California

Earle M. Jorgensen Co.

Perry Kilsby, Inc.
Los Angeles, California

Mapes & Sprowl Steel Co.
Union, New Jersey

Metal Goods Corporation
St. Louis, Missouri

Miller Steel Company, Inc.
Hillside, New Jersey

A. B. Murray Co., Inc.
Elizabeth, New Jersey

C. A. Russell, Inc.
Houston, Texas

Ryerson, Joseph T. & Son, Inc.
Chicago, Illinois

Solar Steel Corporation
Cleveland, Ohio

Steel Sales Corporation
Chicago, Illinois

Tubular Sales
Detroit, Michigan

Ward Steel Service Company
Dayton, Ohio

Pittsburgh Steel Company

Grant Building • Pittsburgh 30, Pa.

DISTRICT SALES OFFICES

Atlanta, Chicago, Cleveland, Dayton, Detroit, Houston, Los Angeles, New York, Philadelphia, Pittsburgh, Tulsa, Warren, Ohio

Circle 436 on Page 19

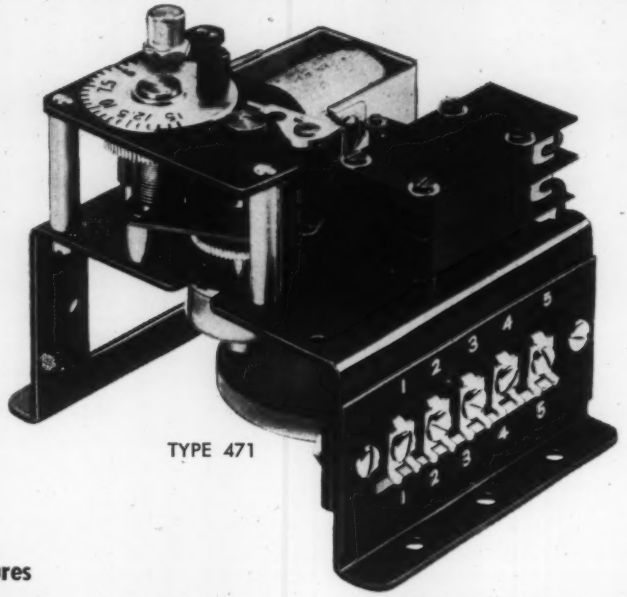
New adjustable time delay relay provides wide selection of time ranges

The new Cramer Type 471 Time Delay Relay provides an accurate, adjustable time delay between the operation of a control circuit and the subsequent closing or opening of one or two load circuits. Through selection of external wiring connections, the unit offers broad application flexibility and excellent accuracy at modest cost. Some typical uses include control of machine tools, batch processes, heat treating, automatic mixers, electronic devices, and signalling equipment of many kinds.

Operation

Type 471 is powered by a Cramer synchronous motor which drives precision-cut timing cams through a clutch, from a starting point set by a dial knob. The cams rotate at constant speed to a zero point, where the load switch is transferred. An instant later, a second cam opens the motor circuit. The clutch stays engaged, and the unit does not reset until the operator either opens the clutch circuit for the direct-clutch model, or closes the clutch circuit for the reverse-clutch model.

The direct-clutch unit resets automatically on power interruption, and repeats its complete cycle when power is restored. The reverse-clutch unit simply suspends operation and, when power returns, proceeds to complete the same time interval. Resetting is accomplished by a coil spring which drives the cam carriage back to a movable stop which is positioned by the dial knob. The stop location determines how quickly the cams will reach the switch actuation points, and so determines the timed interval.



TYPE 471

Features

TIME RANGES — 15 seconds to 24 hours.

ADJUSTMENT RANGE — 90% of full scale.

ACCURACY — within 2% of full scale.

RESET TIME — approx. ⅓ second or less.

LOAD SWITCHES — snap-acting SPDT, 10A 125V or 5A 250V AC, non-inductive.

MOTOR & CLUTCH — 115/220V, 25, 50 and 60 cycles. Reverse clutch optional.

GEARS — case-hardened steel, for life in excess of a million operations.

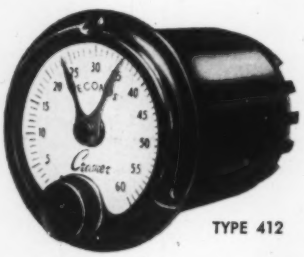
For details, write for your free copy of Bulletin PB-471.

TIME RANGES AND MINIMUM SETTINGS

TIME RANGE	DIAL DIVISIONS	MINIMUM SETTING
15 sec.	½ sec.	1.5 sec.
30 sec.	1 sec.	3 sec.
60 sec.	2 sec.	6 sec.
5 min.	10 sec.	30 sec.
15 min.	30 sec.	1.5 min.
30 min.	1 min.	3 min.
60 min.	2 min.	6 min.
2 hrs.	5 min.	12 min.
5 hrs.	15 min.	36 min.
12 hrs.	30 min.	1¼ hrs.
24 hrs.	1 hr.	2½ hrs.

FOR EXTREME ACCURACY PLUS WIDE SELECTION OF RANGES

Type 412 performs essentially the same functions as Type 471, except that it is designed for panel mounting, extreme accuracy, heavier loads, and 100% adjustability over the entire time range of each unit. Eleven full-scale time ranges are available, from 6 seconds to 24 hours. Overall accuracy is within plus or minus ½ of 1% of full scale, exclusive of setting errors. Repeat accuracy is within plus or minus ¼ of 1% of full scale on 30 second and longer ranges, and ½ of 1% of full scale on faster timers. The fully enclosed dial carries a red pointer to indicate the setting, a black pointer to indicate timing progress. The open blade SPDT load switch is rated 15A 125V, 10A 250V AC, and can handle inrush currents up to 40 amperes. A second load, operating within 1% of full-scale time following the first load, can be controlled from the motor switch itself. Internal SPST seal-in contacts permit operation from a 1/10-sec. control pulse if desired. Direct or reverse clutch operation is as described for Type 471.



TYPE 412

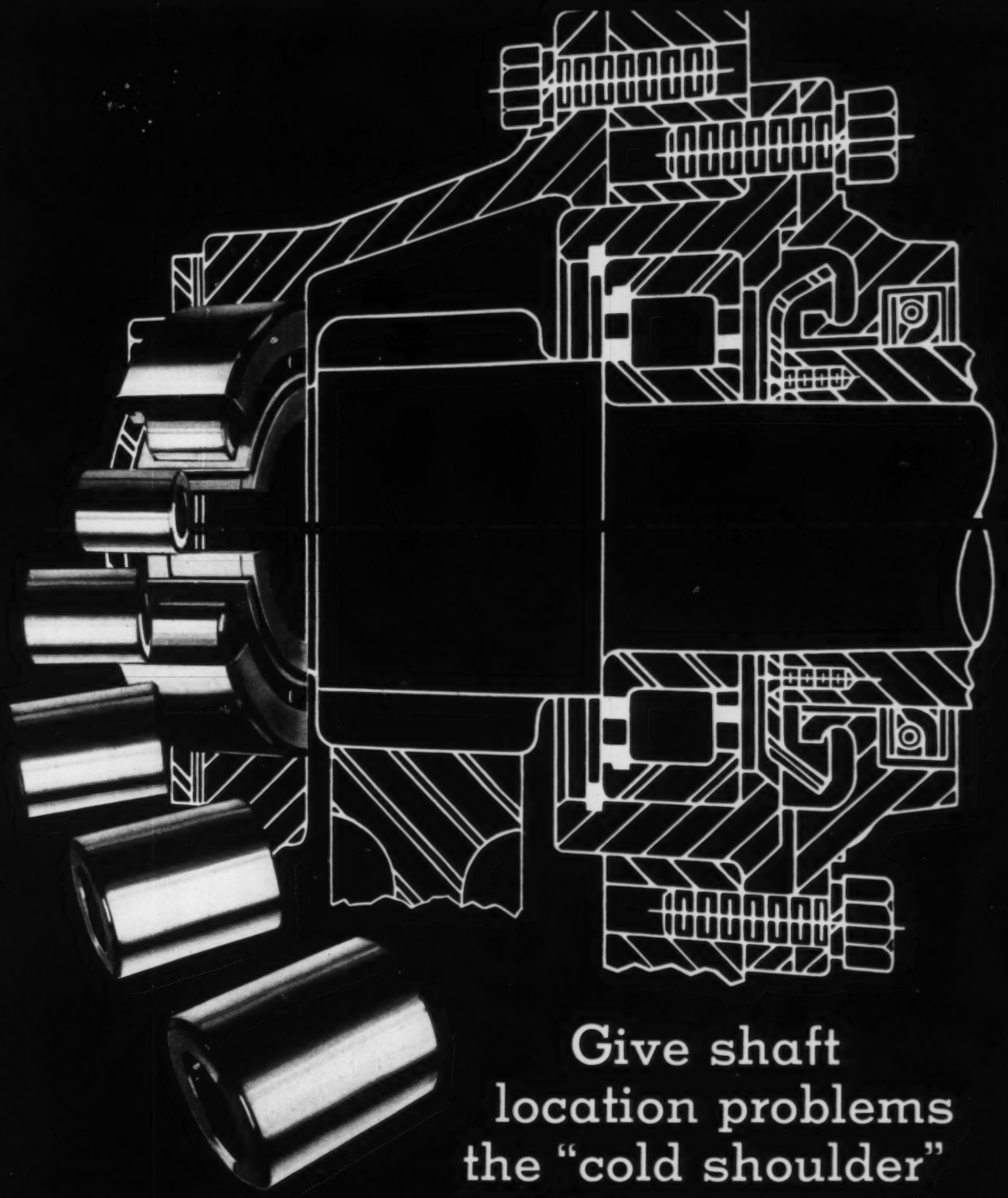
CRAMER CONTROLS

CORPORATION

Box 6, Centerbrook, Connecticut

Circle 437 on Page 19

Circle 438 on Page 19→



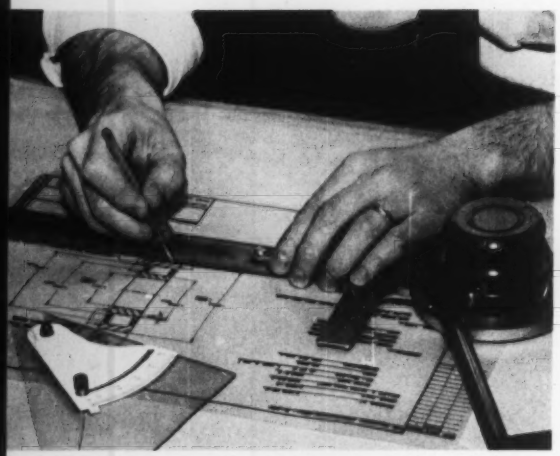
Give shaft
location problems
the "cold shoulder"
with cylindrical

HY-ROLL

ROLLER BEARINGS

NO BEARING ADJUSTMENT

when you locate heavy shafts with

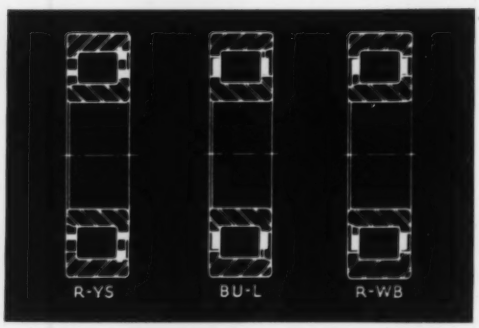


Every design engineer is familiar, of course, with the unequalled ability of cylindrical roller bearings to carry heavy radial loads. Many do not realize, however, that properly built cylindrical bearings with shouldered races *will also take thrust and locate heavy shafts dependably.*

With today's trend to higher horsepowers and larger shafts, which in turn require heavier bearings, the adjustments necessary when installing angular contact bearings become

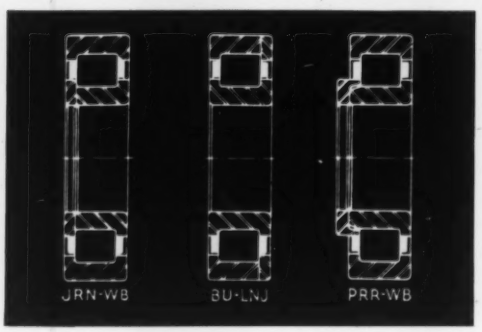
ONE-DIRECTION AXIAL SHAFT LOCATION

In most applications axial shaft location is accomplished by two opposing shouldered-race bearings, each restraining shaft movement in one direction. Depending on individual conditions, the designer has a choice of HYATT Hy-Roll types R-YS, BU-L or R-WB. Type BU-L has conclusively proved its shaft-locating dependability in applications such as engine crankshafts (Fig. 1). Type R-YS gives excellent service in final drive pinions (Fig. 2) and similar applications. All three types are normally mounted in opposing pairs, with sufficient end clearance provided in the assembly to prevent binding in operation.



TWO-DIRECTION AXIAL SHAFT LOCATION

Where the application indicates the use of only one bearing to locate a moving part axially in both directions, the designer may choose from HYATT Hy-Roll Types JRN-WB, BU-LNJ or PRR-WB. Type JRN-WB, for instance, has proved extremely successful in applications such as automobile rear axles (Fig. 3), and heavy duty truck transmission output shafts (Fig. 4). These types offer two basic advantages: (1) They provide the high load-carrying capacity of cylindrical bearings combined with two-way location. (2) They permit a completely non-adjustable fit and eliminate the necessity for shims, washers and locking nuts.



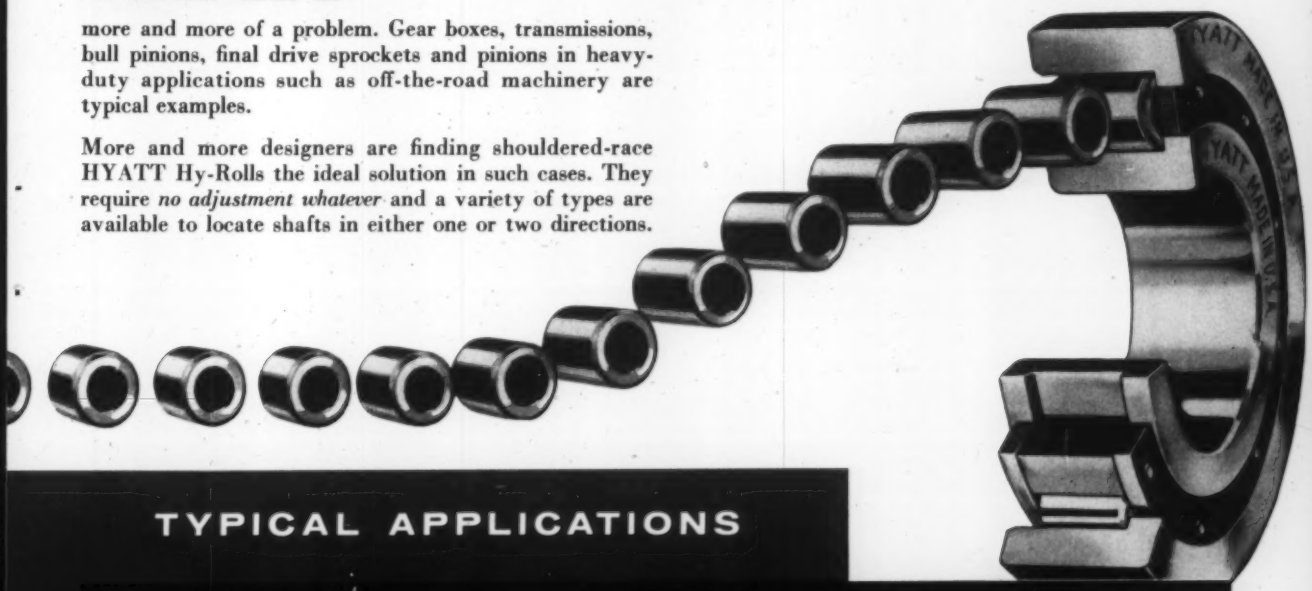
NO BEARINGS CARRY RADIAL LOADS LIKE *CYLINDRICAL*

PROBLEMS

HYATT shouldered-race cylindrical bearings

more and more of a problem. Gear boxes, transmissions, bull pinions, final drive sprockets and pinions in heavy-duty applications such as off-the-road machinery are typical examples.

More and more designers are finding shouldered-race HYATT Hy-Rolls the ideal solution in such cases. They require *no adjustment whatever* and a variety of types are available to locate shafts in either one or two directions.



TYPICAL APPLICATIONS

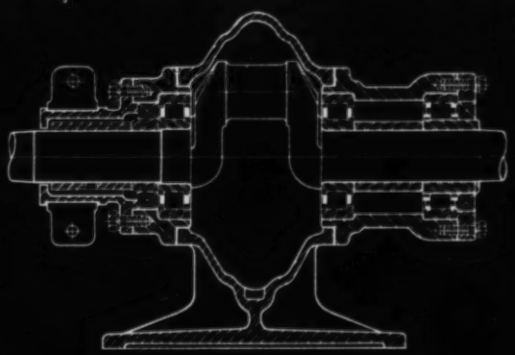


Fig. 1

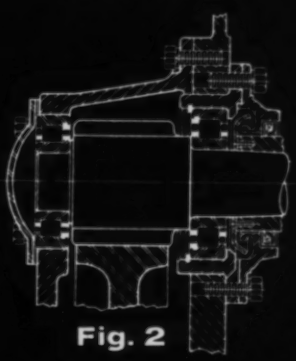


Fig. 2

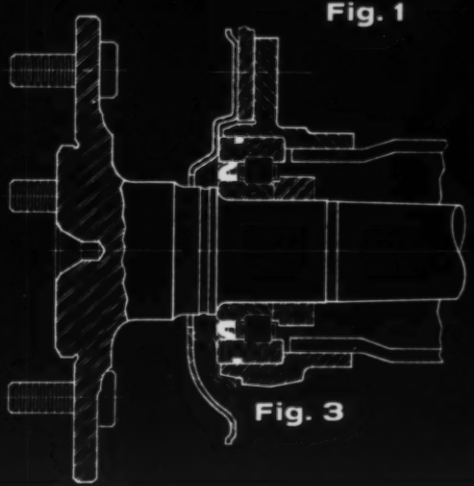


Fig. 3

Fig. 4

BEARINGS . . . AND NOBODY KNOWS THEM LIKE HYATT

YOU CAN DEPEND ON THE ADVICE OF YOUR HYATT SALES ENGINEER

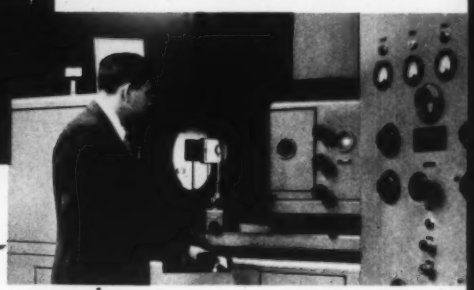
. . . and the bearings he recommends!

Quality DESIGNED

HYATT pioneered the cylindrical roller bearing two-thirds of a century ago, and today HYATT engineers draw on this unequalled fund of accumulated "know-how" to design superior performance into every HYATT Hy-Roll Bearing.

Proper distribution of load within the bearing is an important design factor which lengthens bearing life.

The finest steels must pass rigid metallurgical tests before precision manufacturing processes begin.



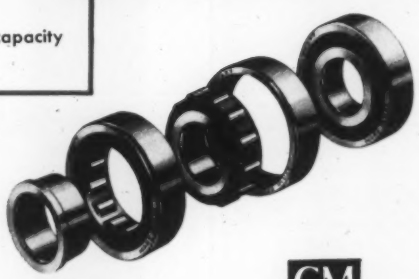
Quality CONTROLLED

The most modern electronic feed-back control of grinding operations, extremely close control of internal diameters and clearances, and uncompromising standards of final inspection assure longer life for every HYATT Hy-Roll.

Remember these *BUILT-IN* HYATT Benefits:

- Higher radial load-carrying capacity, size for size
- Minimum space requirements
- Omitted races are optional
- Shaft location without sacrificing capacity
- Easier assembly and disassembly
- Heavier press fits simplify retainment

THE HEAVIER THE LOAD THE MORE YOU NEED . . .



THE RECOGNIZED LEADER IN CYLINDRICAL BEARINGS

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

HYATT BEARINGS DIVISION • GENERAL MOTORS CORPORATION • HARRISON, NEW JERSEY

Faster reference . . . Faster printmaking

with Recordak Precision Engineering Drawing System

Sharp, clear microfilm image enlarged in Recordak Film Reader is easy to work with—always instantly available

Handy-size photographic, xerographic, or electrostatic prints made from 35mm microfilm are as readable as original drawings.

NOW you can have a complete file of drawings at your fingertips . . . instead of in distant files. You'll be able to check any drawing in seconds in a Recordak Film Reader . . . get handy-size paper prints for pennies a copy—much faster, much cheaper than any other way!

Don't confuse this Recordak System with other methods. Recordak offers unique microfilm picture quality perfected in years of research and development; *35mm microfilm negatives that faithfully reproduce your originals down to last detail!*

All types of drawings, negative and positive prints—old or new, clean or dirty—can be reproduced on Recordak 35mm microfilm. Ends need for costly, larger size films. And the next step—mounting each negative on its own Filmsort aperture card *provides an active drawing file that takes 95% less space.*

Free booklet gives all the facts on this new engineering drawing, available through Recordak and its nation-wide dealer organization.

"Recordak" is a trademark

RECORDAK

(Subsidiary of Eastman Kodak Company)

originator of modern microfilming—
now in its 31st year

MAIL COUPON TODAY

RECORDAK CORPORATION II-2
415 Madison Avenue, New York 17, N. Y.

Gentlemen: Send free booklet describing new Recordak Engineering Drawing System. No obligation whatsoever.

Name_____

Company_____

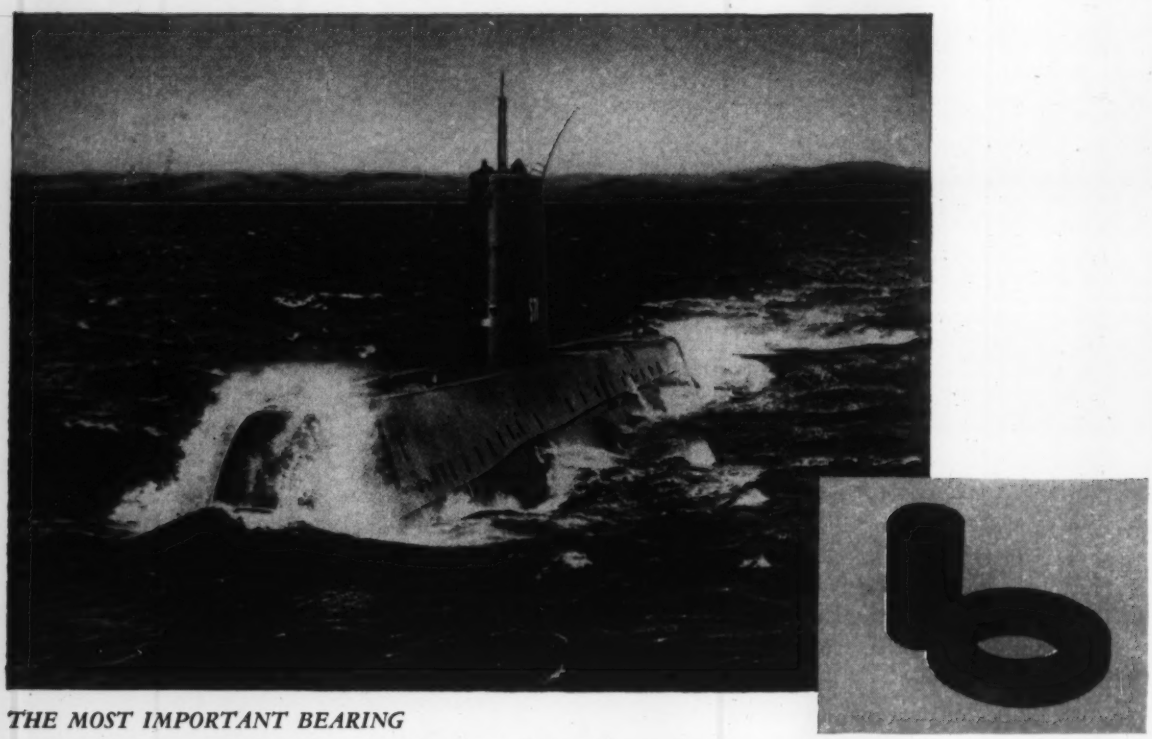
Position_____

Address_____

City_____ State_____

Are your seals or bearings subject to difficult operating conditions?

GRAPHITAR® (Carbon Graphite) has the specific properties needed in difficult applications like these . . .

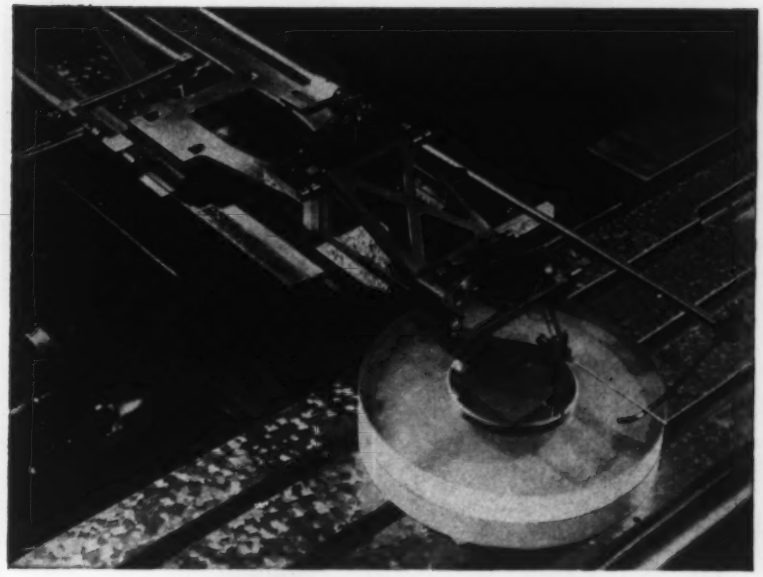


THE MOST IMPORTANT BEARING

Dependability is vital in the power plant of the Navy's atomic submarine U.S.S. Nautilus which has steamed a total of about 50,000 miles of which approximately half has been submerged. In the reactor cooling system of the submarine, special "canned" motor pumps with integrated pump and drive motor were developed by Westinghouse. The bearings in these pumps, which are made of GRAPHITAR, must withstand high speeds, high temperatures, high pressures and must operate for indefinite periods of time without maintenance and with radioactive water as the only lubricant. Westinghouse Electric Corporation engineers—the builders of the Nautilus' atomic power-plant—find that GRAPHITAR is excellent for this difficult bearing application, because of its strength, durability, self-lubricating properties, and chemical inertness. If your design calls for superior bearings, consider the material that worked on such a demanding job.

THE UNITED STATES

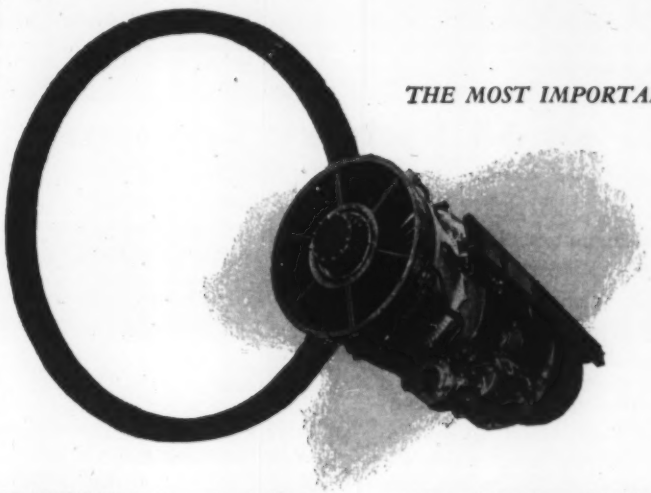
GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES



THE MOST EXACTING BEARING

The Bausch & Lomb Optical Co. of Rochester, N.Y., world renowned manufacturer of precision, scientific optical instruments, employs 10 GRAPHITAR bearings in its unique and highly specialized "ruling engine." The GRAPHITAR bearings provide dimensional stability within one-millionth of an inch for micro-inch accuracy in cutting 15,000-30,000 equidistant lines to the inch on 7" aluminized glass blanks to make diffraction gratings used by science and industry for spectroscopic analysis. Bausch & Lomb engineers have found that GRAPHITAR is unsurpassed as a bearing material where very close tolerances must be maintained and where frequent starting and stopping under heavy loads is a problem. These bearings have contributed greatly to the achievement of extreme accuracy in this application. If you require precision performance as was the case with a "ruling engine" why not use GRAPHITAR?

THE MOST IMPORTANT SEAL



GRAPHITAR is the main shaft seal in the Pratt & Whitney J57 turbojet engine which powers many of our new aircraft, including the huge Boeing B-52 Intercontinental Bomber, which has eight of these turbojets. Naturally, the J57 must perform with utter dependability. One of the components of the J57 is the air/oil seal of GRAPHITAR on the turbine main shaft, and this seal is subjected to tremendous shaft speeds, as well as other taxing physical conditions. GRAPHITAR parts can stand severe operation because they are strong and are virtually unaffected by extremes of speed, pressure, and temperature. If your product develops high speeds or other difficult physical stresses on its parts, perhaps GRAPHITAR components could give it more dependable operation.

THE TOUGHEST APPLICATION

Steel mills are famous for the rough, tough, heavy-duty jobs that they perform. In such difficult steel mill applications as bearings for shear and cut-off tables or coil and slab conveyors, metal-backed GRAPHITAR parts provide exceptional strength and durability. GRAPHITAR alone is a very strong bearing material, and when backed with metal has added resistance to shock. Because of its very low coefficient of friction, GRAPHITAR can operate under heavy loads at high speeds with no lubrication. Can the strength and superb bearing qualities of GRAPHITAR simplify your product design?

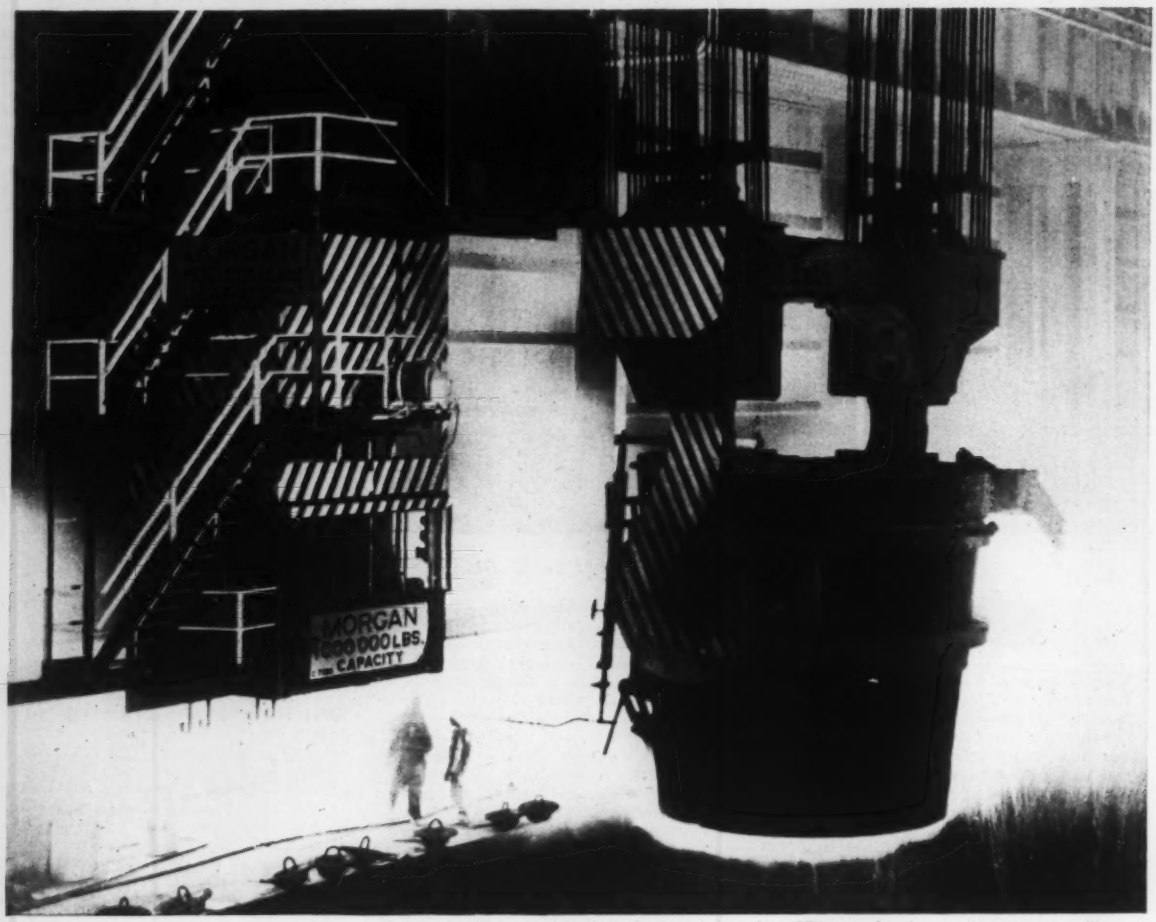
Get your copy of Engineering Bulletin No. 20.

GRAPHITAR is compacted from carbon-graphite powders under great pressures, then furnaced at heats near 4500°F. It can be formed in relatively complex shapes and ground to tolerances as close as .0005". For more information on this strong, light, self-lubricating engineering material, write for our Engineering Bulletin No. 20.

218

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN



Repeated million-pound loads in the intense heat from 375 tons of molten steel, cause no spalling or deformation of Rollway Bearings.

1,122,000 Pounds Ride on 68 Rollway Bearings

One of the largest in the world, this 500-ton Morgan-built ladle crane is Rollway equipped in many positions.

Sixty-eight maximum-type, solid-cylindrical bearings—mounted without inner races—lift and lower the 1,122,000-pound weight of the lifting beam, ladle hooks, ladle and white-hot steel.

Rollway Tru-Rol® type bearings are used in the two General Electric 360 HP – MD-620 Hoist motors which lift the weight of the ladle and its molten metal content.

The maximum-type bearings in the hoisting sheaves are mounted directly on the shaft without inner races, which greatly simplifies assembly for applications of this size.

Thrust bearings in the 25-ton and 75-ton auxiliary crane hooks are standard Rollway precision types with broad-area contact between rollers and plates to prevent Brinelling and assure freedom of rotation under the heaviest loads.

Sheaves ready for assembly on shaft and installation in lifting beam.

For bearings that accomplish the extraordinary in an ordinary manner, write, wire or 'phone Rollway Bearing Co., Syracuse 1, N.Y.

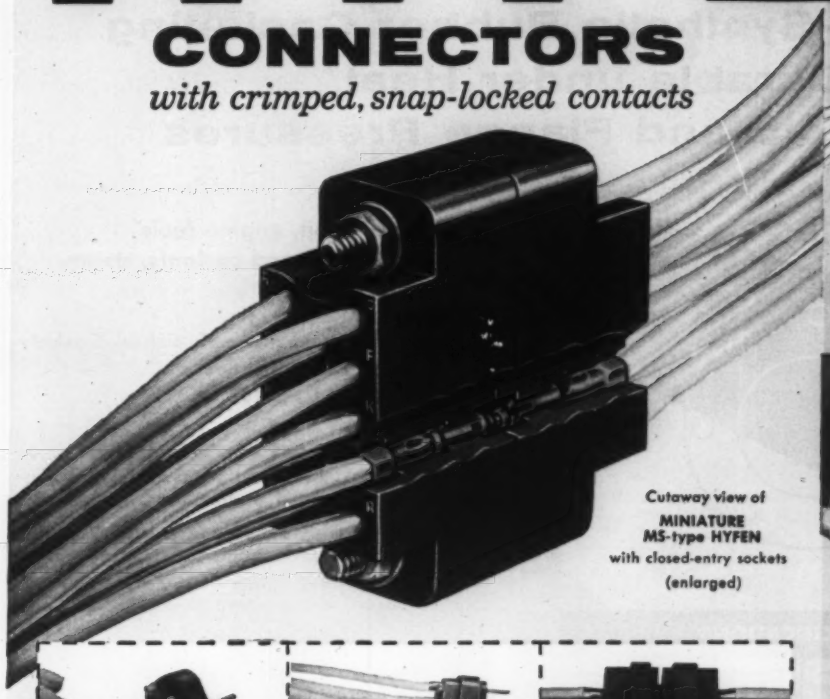
ROLLWAY® BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

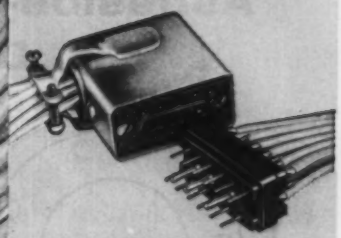
HYFEN T.M.

CONNECTORS

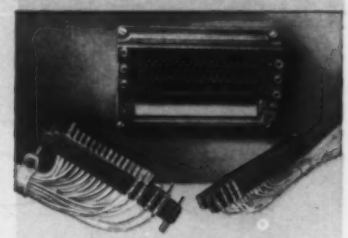
with crimped, snap-locked contacts



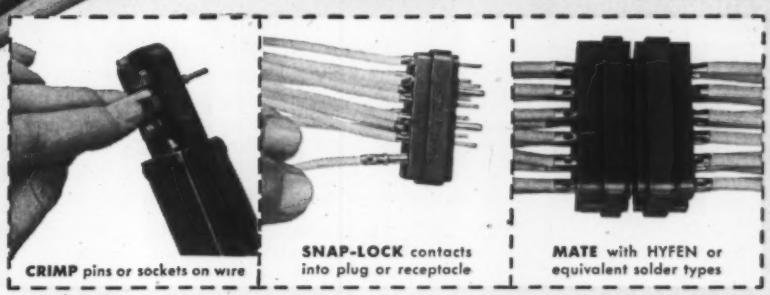
Cutaway view of
MINIATURE MS-type HYFEN
with closed-entry sockets
(enlarged)

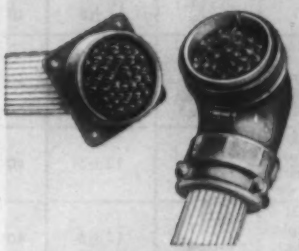


15 contact, multi-purpose connector. Mates with, or replaces existing solder connectors.



Feed-thru, modular design, multiple insert connector. 35 contact inserts, can be removed from frame for easy contact insertion or removal. 5 or 8 insert frames available.





AN-type HYFEN connector, showing HYFEN method adapted to round design.

SAVE WEIGHT, SPACE, TIME—Burndy's HYFEN method brings added Reliability and Versatility to the connector field, allowing the design of lighter and more compact equipment...saving space, weight and time. Pins and Sockets can be bench-installed on the wire and can be snap-locked in place even after the Plug and Receptacle have been mounted on the equipment.

Designed to replace or mate with virtually all existing connectors, including AN, MS, and other Miniature types, the HYFEN meets or exceeds MIL specs.

The HYFEN method ends the high rejection rate inherent with the use of solder ...especially important in today's continuing trend toward miniaturization.

HYFEN types illustrated are typical of those already supplied to the Industry by Burndy. HYFEN connectors are engineered to meet specific requirements. For other types and sizes, contact Burndy.

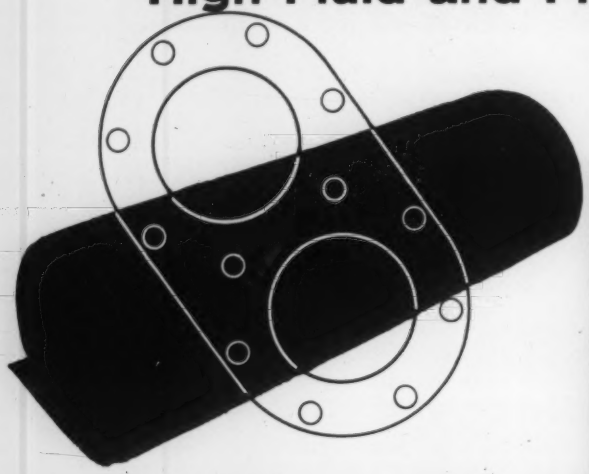
OMATON DIVISION

BURNDY

For detailed information Write or Wire **BURNDY**, Norwalk, Connect., or Toronto, Canada...in Europe: Antwerp, Belgium 58-14

VICTOPAC

Asbestos-Synthetic Rubber Gasketing Durable under Heat, High Fluid and Flange Pressures



Seals against oil, engine fuels (liquid or vapor) and coolants, steam, hot or cold water

Supplied in Sheets . . . or Finished Gaskets Made in standard thickness:
1/64" — 1/32" — 1/16" — 3/32" — 1/8"

This tough, completely homogeneous sheet packing is composed of long-fiber asbestos and synthetic rubber, bonded under heat and pressure.

While thoroughly dense in structure, Victopac has sufficient compressibility for effective sealing under light or heavy flange loading. Its resistance to heat permits usage where plant fiber packings deteriorate.

Made in 7 types — Typical uses

Victopac is widely specified for automotive and industrial machinery applications. Choice of seven basic types provides economical sealing for each use. All types conform to SAE-ASTM specifications and are certified to federal, military or customer specifications where needed.

Typical applications include speed reducers, transmissions, differentials, gear case covers, pipe flanges, refrigeration, pumps, oil coolers, internal combustion engines, etc. Victopac's uses are almost unlimited.

Test samples supplied free

Your inquiry, stating proposed application, will bring you sample sheets of recommended type with full technical data. Request through your Victor Sales Engineer or directly to factory.

Victopac is available in sheet sizes 58" x 62½" and 58" x 125". Write for special price list.

Victor Mfg. & Gasket Co., P.O. Box 1333, Chicago 90, Ill. Canadian Plant: St. Thomas, Ont.

CONDENSED SPECIFICATIONS

Type	SAE-ASTM Spec.	% Compression 5000 Psi. Load	Recovery %	Minimum Original Tensile	Max. Thickness Change in ASTM Oil No. 1— 5 hrs. at 300 deg. F.
1	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
1B	G-1111-1 (Federal Spec. HH-P-46A *P1161A	12±5	40	1800 psi.	20%
2 Graphite coated, one side	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
3 Graphite coated, two sides	G-1111-1 *P1161A	12±5	40	1800 psi.	20%
50V	G-1122-1 (AMS 3232F) (Navy Spec. 33-P-13c) *P1141A	12±5	40	2000 psi.	10%
60V	G-1123-1 (AMS 3230 and 3231) *P1151A	12±5	40	2000 psi.	15%
70V	G-1122-1 (AMS 3232F) *P1141A	12±5	40	2000 psi.	10%

*Latest ASTM No. D1170-58T, SAE No. 90R and MIL-G-12803A specifications.

VICTOR

Sealing Products *Exclusively*

1909 — 1959 50th ANNIVERSARY GASKETS-OIL SEALS

GASKETS • PACKINGS • OIL SEALS • MECHANICAL SEALS

Circle 442 on Page 19

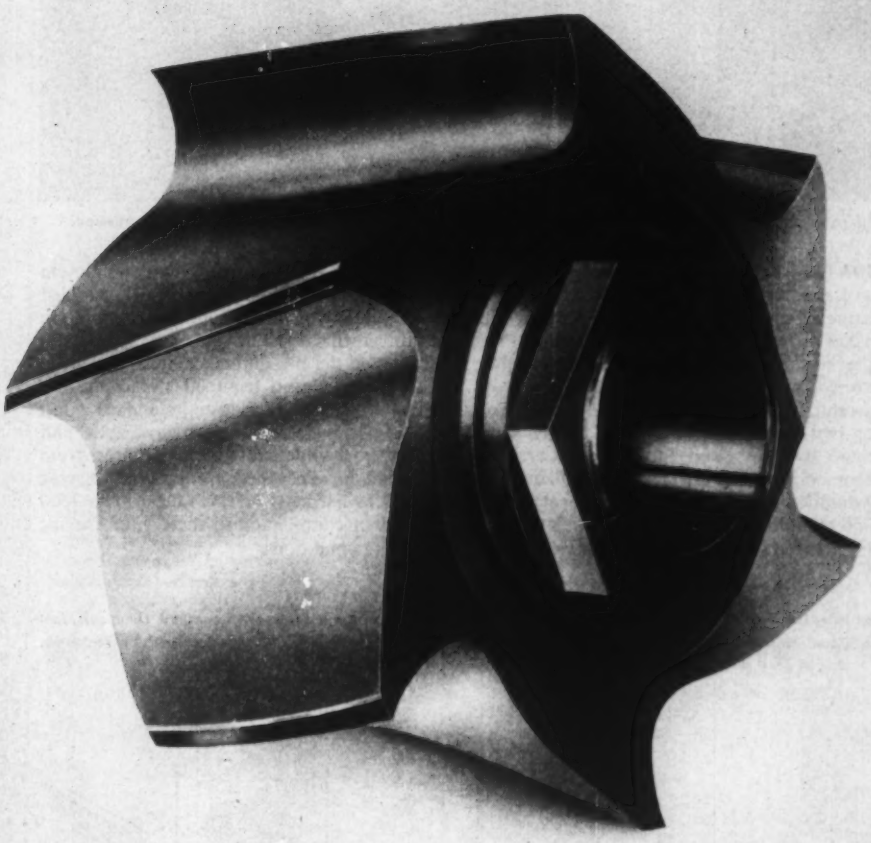
Circle 443 on Page 19→

NOW: Higher strength costs you less! Specify TENZALOY*, the self-aging aluminum alloy that needs no heat treatment! TENZALOY is a corrosion resistant aluminum alloy that ages at room temperatures, gives high strength properties superior to those normally obtained only by solution treating, quenching and artificial aging. And these properties are stable, proved by conclusive test data taken over a ten year period. No special foundry techniques are required. No fluxes. Castability is excellent with sand cast and plaster molds, and many permanent molds. TENZALOY will not "grow". It takes a brilliant polish and anodizes clear white. Write for TENZALOY Bulletin No. 103 or call one of Federated's 22 sales offices. Federated Metals Division, 120 Broadway, New York 5. In Canada: Federated Metals Canada, Ltd., Toronto and Montreal.

FEDERATED METALS DIVISION OF

ASARCO

AMERICAN SMELTING AND REFINING COMPANY

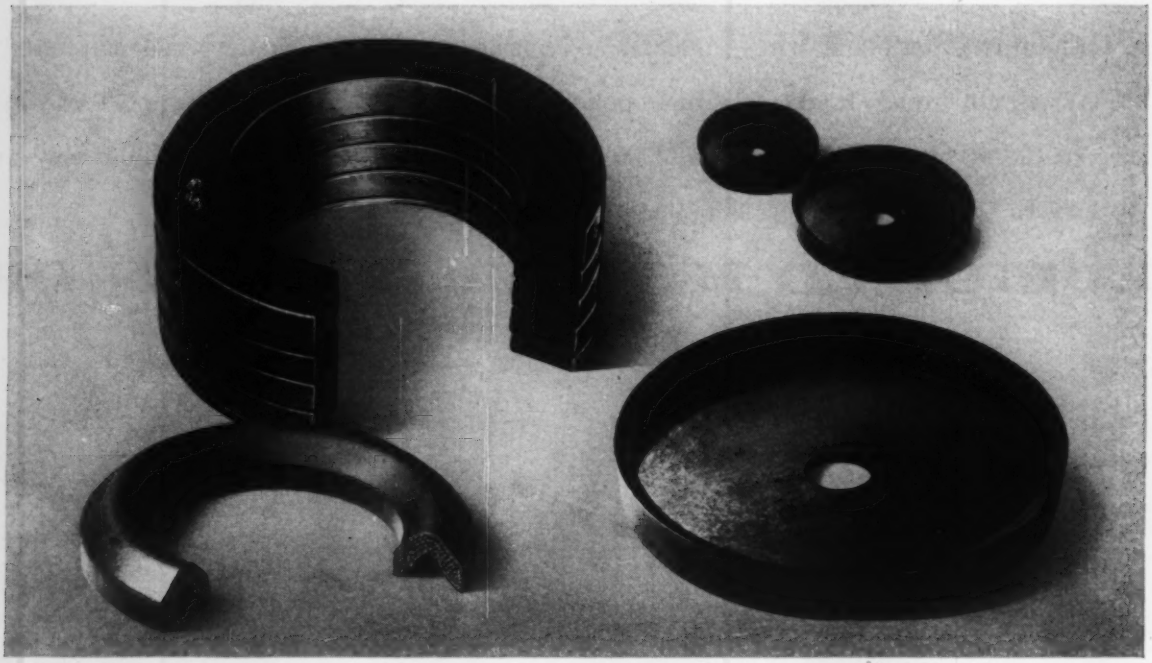


**TENZALOY is one of a complete range of Federated aluminum casting alloys. These and hundreds of other quality controlled non-ferrous metal products are produced in the 11 plants of the Federated Metals Division.*

CUT COSTS, IMPROVE DESIGN AND PERFORMANCE WITH R/M PRODUCTS

PACKINGS

Complete information on packings shown and many others is given in free booklet. Send for it today.
Packing Division, Raybestos-Manhattan, Inc.
Passaic, N.J.



R/M Vee-Flex Rings seal automatically and will not roll.

R/M Fabric Piston Cups are precision molded and cleanly trimmed.

Precision quality control means you can rely on R/M V-rings and piston cups

R/M Vee-Flex Rings give better performance and cut maintenance costs. Convex curvature of the surface which touches next ring makes them self-sealing, self-adjusting. Pressure stroke produces a seal against stuffing box wall and adjacent ring. Friction is reduced on return stroke. Precision molded and trimmed for best possible fit. Fabric is deeply penetrated by compound for longer wear. Use them on steam or air rods, hot oil pumps, hydraulic rams, outside-packed plunger pumps, food handling machinery, accumulator and elevator rams on oil or water service.

R/M Fabric Piston Cups provide minimum friction, long life, and accurate fit. Molded from a variety of rubber synthetics with fabric reinforcements to suit your specific requirements. See the big difference: clearly defined contours and cleanly trimmed edges—proof of strict adherence to industry standard sizes. R/M Fabric Piston Cups fit hydraulic and pneumatic cylinders ranging in diameter from ½ to 12 in. They are produced in varying degrees of hardness for pressures up to 1500 psi and in compounds to meet your specific operating conditions.

The complete R/M line includes packings and gasket sheets for use with gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's experienced engineers for help in your packing problems.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

Industrial and Automotive Hose

Conveyor Belts

Circle 444 on Page 19

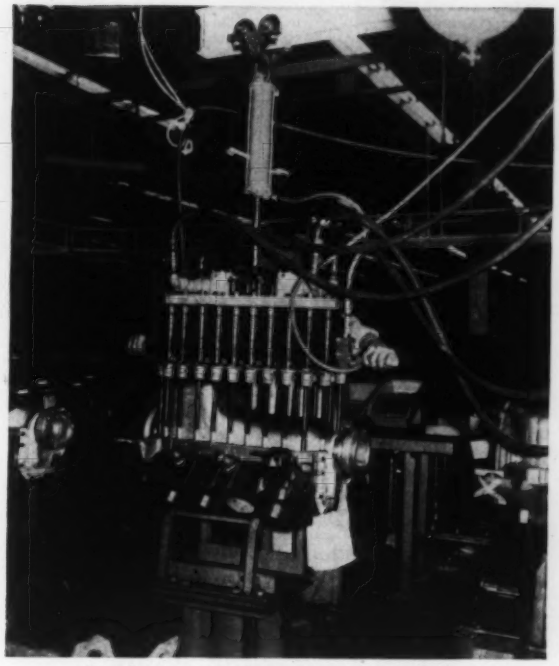
SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

RUBBER

Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division, Raybestos-Manhattan, Inc.
Passaic, N.J.

PLASTICS

Write for free booklet, which provides valuable information on a variety of R/M plastic products.
Plastic Products Division, Raybestos-Manhattan, Inc.
Manheim, Pa.



Homoflex Hose, manufactured by Manhattan Rubber Division, is engineered for use on air-driven tools.

"Teflon" diaphragms protect Salk vaccine from contamination during long manufacturing process.

R/M Hose engineered for many purposes

For general use with air, water, gases . . . special types for handling oils, acids, chemicals . . . or non-spark, high heat or non-contaminating construction—R/M has a rubber hose for *every* application.

For example, *Flexlon* R/M rubber hose, "Teflon"* lined, offers complete resistance to virtually all chemicals and solvents. *Allflex* is a versatile all-purpose hose for handling fluids and gases—even mild chemicals. *Homoflex*, lightweight and easily handled, is ideal for air tools. *Super-Master BW* Burstproof Steam and Air Hose has special wire braid reinforcement for rugged, high pressure service.

R/M also makes flanged flexible pipe and rubber expansion joints. Whether it's hose, transmission or conveyor belts, V-belts, Poly-V Drive® or molded rubber products, depend on R/M's 60 years of leadership in rubber.

R/M "Teflon" Valve Diaphragms protect purity of polio vaccine

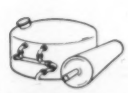
Salk polio vaccine must be kept absolutely pure and sterile during the 130 days needed to manufacture and test it. To help guard against contamination, valves are sealed with thin, long-lasting diaphragms of "Teflon," developed by Raybestos-Manhattan. "Teflon" is ideally suited for this exacting application. It is strong, flexible, chemically inert, easily sterilized, and well able to withstand the required temperatures, ranging from 5 to 150°C.

Many other R/M "Teflon" products are also at work for aviation, missile, electrical and electronic industries. Among these are flexible thin-wall tubing (plain or covered); tape; custom-machined parts; rods and gaskets; expansion joints and flexible couplings; bondable "Teflon" sheet and other products. Raylon, an R/M mechanical grade of "Teflon," has many of the characteristics of virgin "Teflon."

*A Du Pont trademark

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C.
Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada



Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

Engineered Molded Rubber and Plastics

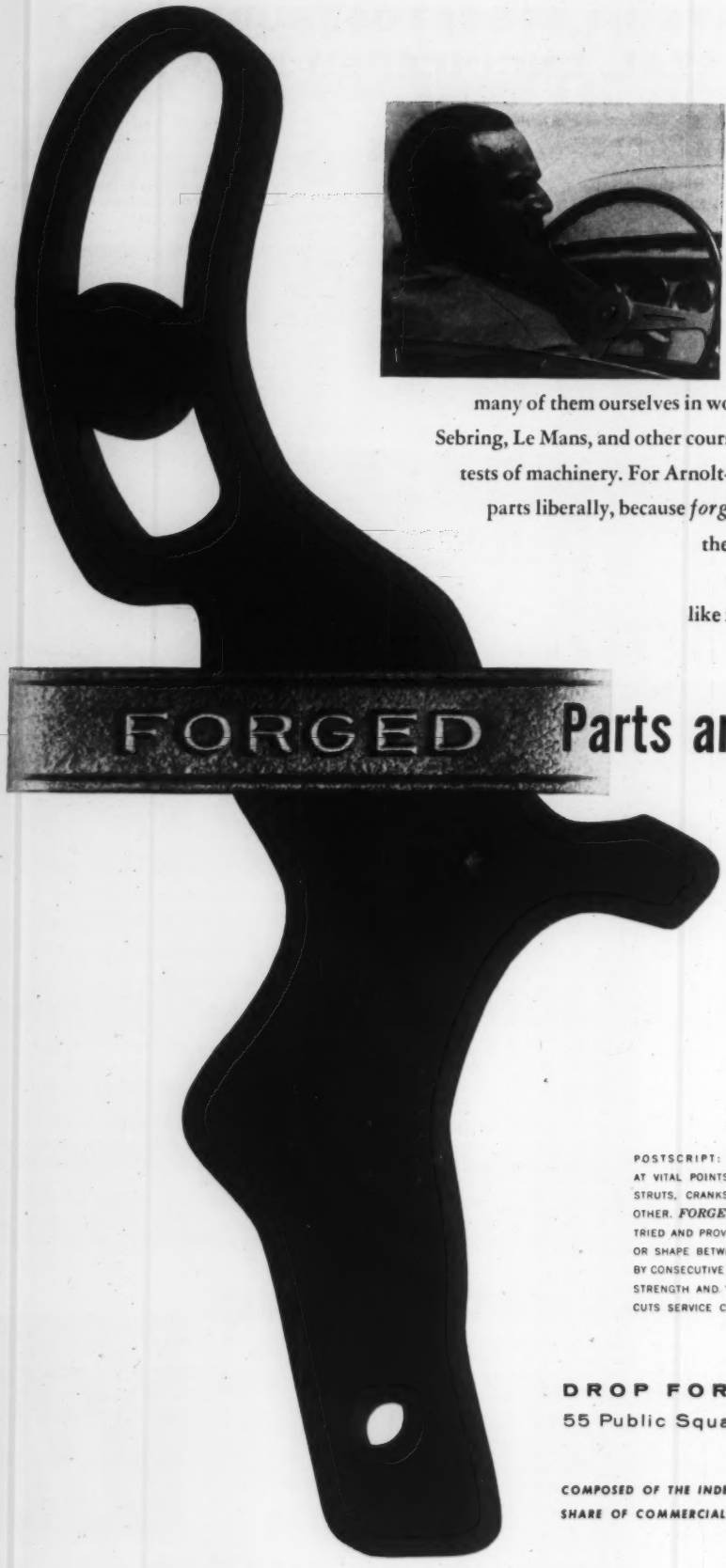
R/M

Circle 445 on Page 19

Circle 446 on Page 19

S. H. ARNOLT, *designer and builder of the Arnolt-Bristol sports car, and internationally known Indiana sportsman.*

"We design and build Arnolt-Bristols, and drive many of them ourselves in world-famous road races, at Sebring, Le Mans, and other courses. These road races are grueling tests of machinery. For Arnolt-Bristol cars, we use *forged* parts liberally, because *forged* parts are dependable when the going is tough. To win, to win safely, we depend on dependable parts, like forgings."



FORGED Parts are Dependable

when the going is tough

POSTSCRIPT: THE PRODUCTS OF THE FORGING INDUSTRY ARE FOUND AT VITAL POINTS OF MODERN CONVEYANCES AND MACHINES...LEVERS, STRUTS, CRANKSHAFTS, GEARS. THE FORGING PROCESS IS UNLIKE ANY OTHER. *FORGED* PARTS START WITH REFINED METALS—METALS ALREADY TRIED AND PROVED. THESE METALS ARE GIVEN ALMOST ANY DESIRED FORM OR SHAPE BETWEEN IMPRESSION DIES, UNDER ENORMOUS PRESSURE OR BY CONSECUTIVE BLOWS FROM POWERFUL HAMMERS. THE RESULT IS ADDED STRENGTH AND TOUGHNESS...WHICH PERMITS WEIGHT-SAVING DESIGNS, CUTS SERVICE COSTS, HELPS PROVIDE SAFETY IN A HIGH-SPEED WORLD.

DROP FORGING ASSOCIATION

55 Public Square Cleveland 13, Ohio

COMPOSED OF THE INDEPENDENT COMPANIES PRODUCING THE MAJOR SHARE OF COMMERCIAL FORGINGS IN THE UNITED STATES & CANADA

Circle 447 on Page 19

the most important advance in couplings since Sier-Bath's flangeless design!

new

nyflex

Flexible Gear Couplings WITH NYLON SLEEVES

- No lubrication required
- Takes more misalignment than standard gear couplings
- Top performance in horizontal or vertical positions
- Weighs only 3½ pounds
- Low in price
- Speeds to 5000 rpm
- 1⅛" max. shaft capacity

ONLY 5 PARTS

Assembles, disassembles in seconds, no special tools needed!

This NYFLEX flexible gear coupling has a one-piece sleeve weighing only four ounces! The entire assembly, including high-strength steel hubs and retaining rings, weighs just 3½ pounds. It's the lightest, most compact flexible gear coupling you can buy. Another outstanding "first" from Sier-Bath, pioneer producer of flangeless, one-piece flexible gear couplings.

The NYFLEX coupling gives you several innovations in design and performance. It never needs lubrication . . . Takes almost 5° misalignment . . . Can be run equally well in either horizontal or vertical installations . . . Operating temperatures may be as high as 150°F . . Wide range of horsepower capacities and shaft speeds to 5000 rpm. And it's priced as low as *half the cost* of comparable all-steel couplings! Ten bore sizes available NOW from stock.

Bulletin N-1 gives the complete story of the new Sier-Bath Nyflex coupling. It's yours for the asking.

Sier-Bath GEAR AND PUMP COMPANY, INC.
Founded 1905 Member A.G.M.A.
9254 Hudson Blvd., North Bergen, N. J.

MEL-TROL®

gives you **design insurance**
on parts like this
jet engine ring

This design calls for a high temperature alloy bar to be bent and flash-welded into a ring. When it is machined to cross section, as much as 40% of the metal is machined away.

In a part like this, you really end up with nothing more than the core of the bar with which you start . . . which was once the core of an ingot.

That is why, in almost every case, poor service or high reject rates in parts like this can be traced to inconsistency in the ingot. You get a good part *only* when the steel ingot itself is consistent through the core all along the centerline. That's what MEL-TROL gives you.

MEL-TROL achieves greater uniformity in ingots than any other known system of steelmaking today. It is a process combining an exclusive, patented ingot mold design with an integrated system of quality controls. The result is the most complete freedom from variation in toughness and strength between surface material and the ingot core ever attained in commercially available high temperature alloys.

Mechanical properties at both room and elevated temperatures are also more consistent than in conventionally made alloys. When you specify MEL-TROL alloys, you're specifying—and insuring—the best performance you can put into high temperature parts. The Carpenter Steel Company, 120 W. Bern Street, Reading, Pa.

Carpenter STEEL

The Carpenter Steel Company
Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.

Circle 449 on Page 19

Hoover announces 3L00 extra light bearings

Now, America's quality bearings come in compact proportions designed to save space! Hoover's new 3L00 series extra light ball bearings provide the solution to bearing problems calling for maximum bore size and minimum housing area. They have outer diameter and width dimensions that are substantially smaller than those of standard light, medium or heavy series bearings of equal bore size.

Hoover 3L00 extra light ball bearings are available in a wide range of popular sizes in open, shielded and sealed types, including lubricated-for-life bearings with Hoover-developed contact seals of TEFLON. For complete information, return the coupon below.

Hoover quality is outstanding!

Micro-Velvet balls are made of selected high-carbon chrome alloy steel, uniformly hardened, and finished so perfectly that roundness and diameter are accurate within millionths of an inch.

Hoover Honed raceways, on both inner and outer rings, are super-smooth, superbly finished. Precision matching of ball complements and raceways assures hushed quietness, long life, superior Hoover performance.

Micro-Velvet and *Hoover Honed* are Hoover trademarks. TEFLON is a DuPont trademark for its fluorocarbon resins.

hoover

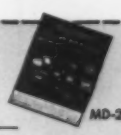
BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Los Angeles Sales Office and Warehouse:
2020 South Figueroa, Los Angeles 7, California

Hoover Ball and Bearing Company
5400 South State Road, Ann Arbor, Michigan

Please send new Bulletin 108, which describes Hoover 3L00 extra light bearings.



MD-2

Name_____

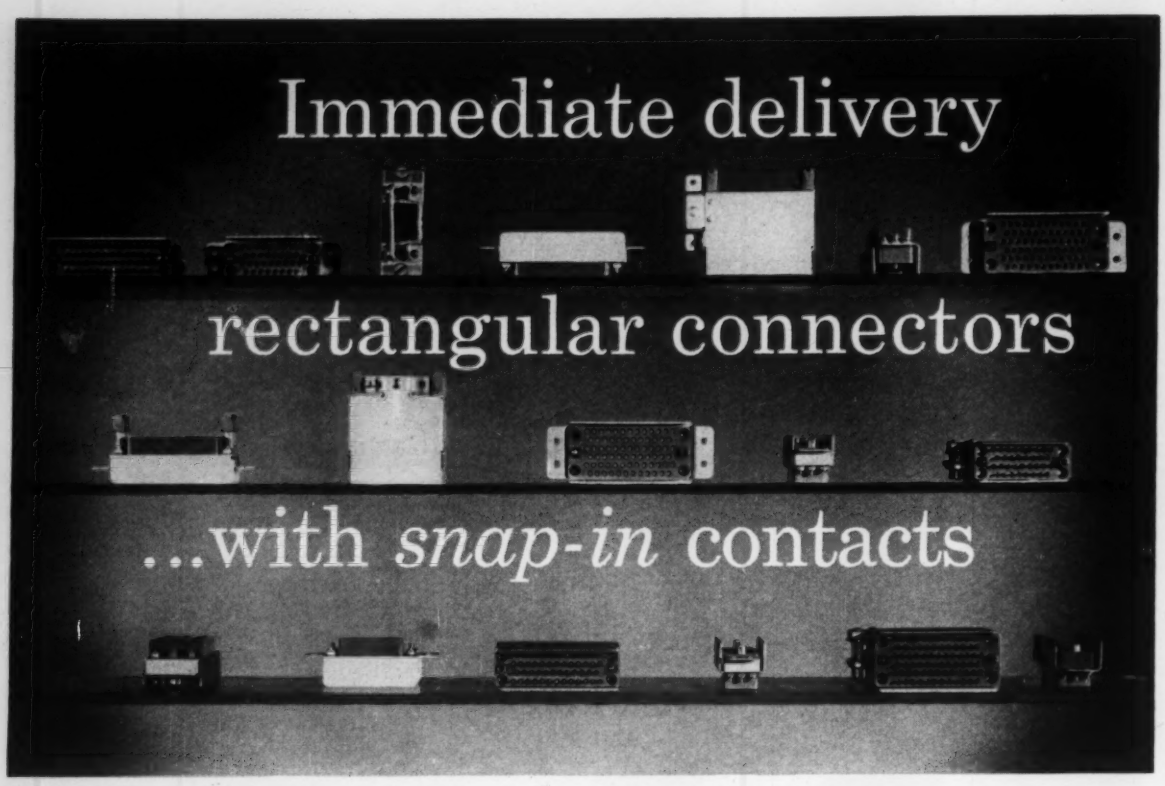
Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 450 on Page 19



Available now... CEC electrical connectors in large or small quantities to satisfy an exceptionally wide variety of applications—flush- or surface-mounting types... with jackscrews or guide pins... straight- or right-angle hoods... in 26-, 34-, 42-, 50-, or 75-pin configurations—all standard types with off-the-shelf availability.

Lightweight, rugged, and dependable, the Series 500-C multi-contact connectors feature easy-to-assemble snap-in contacts which simply push into place, yet permit fast, easy removal with a simple hand tool. A triple retention spring in each contact resists an axial pull of at least 20 lbs.—equal to a cable-harness pull in excess of 1,500 lbs. for a 75-pin connector.

CEC connectors represent the newest concepts of design and materials and employ a modular construction to enhance flexibility of application and speed assembly and installation. Individual contacts accept insulated wires from size 20 to 24, and cables composed of wires from 0.054″ to 0.10″ in diameter are easily accommodated by the connector enclosure. Contacts are gold-plated and can be used with hand, semi-automatic, or automatic crimping methods. CEC connectors exceed the requirements of MIL-C-8384A.

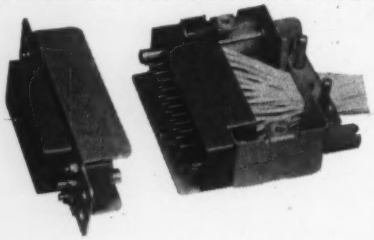
SPECIAL CONNECTORS... If your application requires an unusual or special type connector often demanded by advanced technologies, you are invited to take advantage of CEC's proved experience in the design and manufacture of these custom types... designed for the particular application and and environment you specify.

Write today for complete information on Series 500-C connectors, or call your nearby CEC sales and service office. Ask for Bulletin CEC 4004-X12.

Electro Mechanical Instrument Division CEC

CONSOLIDATED ELECTRODYNAMICS *300 N. Sierra Madre Villa, Pasadena, Calif.*

FOR EMPLOYMENT OPPORTUNITIES WITH THIS PROGRESSIVE COMPANY, WRITE DIRECTOR OF PERSONNEL



SERIES 500-C CONNECTOR... Removal of portal door exposes interior of connector for contact insertion, removal, or replacement, and allows quick inspection and adjustment of cable-harness.

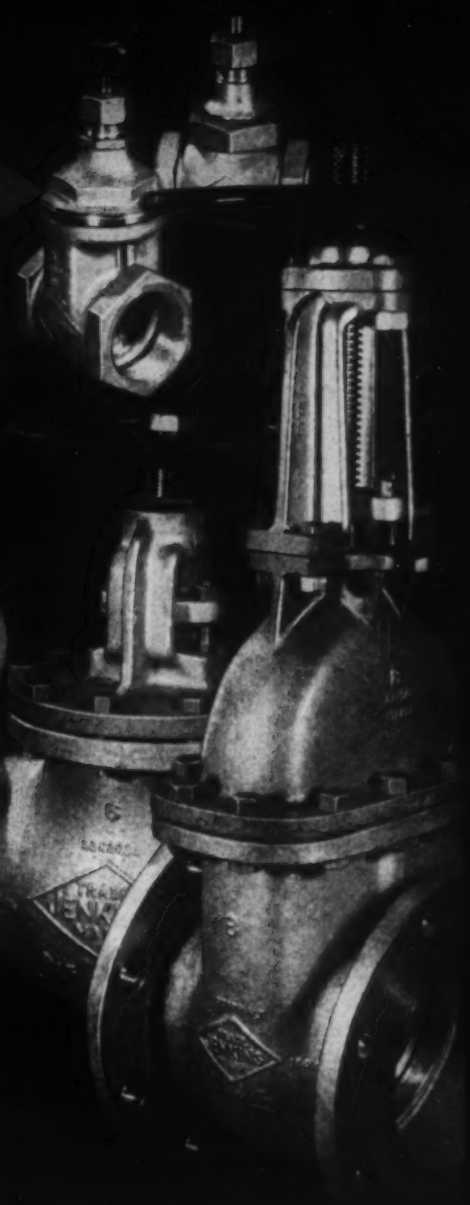
Circle 451 on Page 19

Circle 452 on Page 19→

It's a good feeling to see this trusted mark on your

STAINLESS STEEL VALVES *too*

JENKINS



PATTERNS AND ALLOYS TO SATISFY MOST INDUSTRIAL NEEDS

For solid reasons, men who ask for the best in Stainless Steel Valves have full confidence when they see the Jenkins Diamond. For almost a century this mark has appeared only on valves made to peak standards of quality in design . . . in castings . . . in machining. JENKINS standards, enforced by the most rigid inspection and testing in the valve industry.

Valves of corrosion resistant stainless steels have been made to those high standards by Jenkins for a quarter of a century. And today, the line of Jenkins Stainless Steel valves includes types and alloys to fully satisfy most service requirements.

They are available through the same leading distributors everywhere who sell Jenkins Valves of Bronze, Iron and Cast Steel. Jenkins Bros., 100 Park Avenue, New York 17, N. Y.

NEW JENKINS
STAINLESS STEEL
VALVE CATALOG
Send for your
copy today

Anodized grille of Penmetal Multimesh blends elegance with strength

Color and texture are excitingly combined in this golden grille of Penmetal expanded aluminum. The new patented Multimesh pattern has depth and variety. Gives, in fact, an air of elegance to the handsome "hi-fi."

Penmetal expanded metal has the strength to withstand the abuse of everyday use; the rigidity to span large areas in an unbroken sweep. What's more, the open mesh permits free passage of sound. The color is an integral part of the metal surface . . . for permanent brightness.

Get one-of-a-kind beauty for *your* product with any of the new Multimesh patterns: Crystal, Pendant, Garland.* Easy to work with. Easy on your pocketbook.

Folder 516-EM gives sizes and dimensions of Multimesh. Write for a FREE copy today.

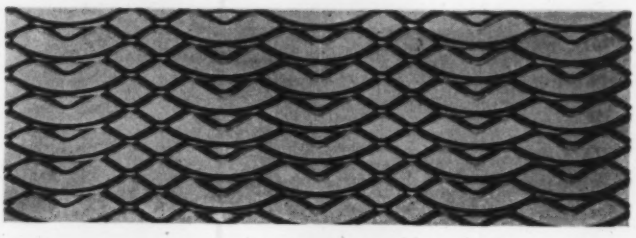
PENN METAL COMPANY, INC.

General Sales Office:
40 Central Street, Boston 9, Mass.
Plant: Parkersburg, W. Va.
District Sales Offices: Boston, New York, Philadelphia, Pittsburgh, Chicago, Detroit, Dallas, Little Rock, Seattle, San Francisco, Los Angeles, Parkersburg

Penmetal

a name to remember

"Stereotron" stereophonic unit by Griffith Company, Parkersburg, W. Va., features a gold anodized grille of Penmetal's Pendant Multimesh.



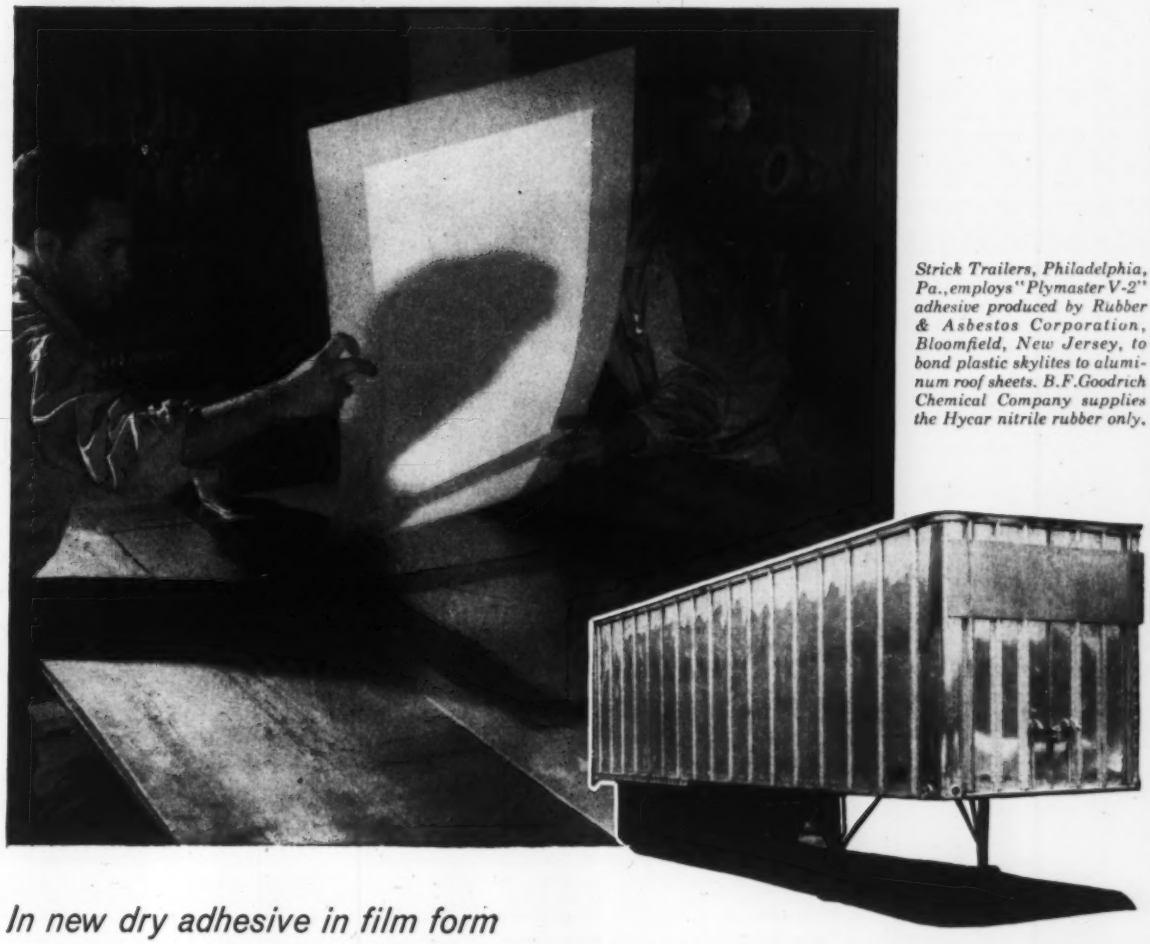
*All designs are patented.

PM-199

Circle 453 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*



Strick Trailers, Philadelphia, Pa., employs "Plymaster V-2" adhesive produced by Rubber & Asbestos Corporation, Bloomfield, New Jersey, to bond plastic skylites to aluminum roof sheets. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber only.

In new dry adhesive in film form

Hycar rubber speeds and simplifies bonding

Mass-production bonding of flat surfaces as unlike as plastic and aluminum demonstrates the efficiency of this new dry adhesive in film form. It uses Hycar nitrile rubber to produce a bond between plastic skylites and aluminum roof sheets on both trailers and truck bodies. The adhesive manufacturer says Hycar provides a higher combination of cohesion and adhesion strengths than any other copolymer tested.

The adhesive comes in rolls from which sheets can be cut to exact size. No need for expensive liquid-handling equipment. You get a much cleaner, faster operation. The film adhesive can be reactivated with common solvents, heat or pressure to achieve tensile strengths as high as 1500 psi.

The exceptional qualities of Hycar nitrile rubber have led to produce improvements in many fields. For more information, write Dept. CM-1, B. F. Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
Reg. U.S. Pat. Off.
Rubber and Latex

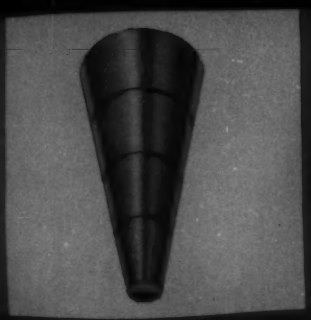
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON polyvinyl materials • HYCAR rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

Circle 454 on Page 19

Circle 455 on Page 19→



What the designer conceives... aluminum achieves!

FUNCTIONAL PARTS BECOME BEAUTY ACCENTS BRILLIANT COLOR— ALUMINUM

Aluminum screw machine knobs—economical and versatile for your high quality products—offer designers infinite possibilities for styling beauty accents both with shape and with color.

In finished shapes such as the examples shown, aluminum gives sharp, clean lines . . . unusually fine "as machined" finish . . . plus the quality feel of solid metal. Low tooling cost, particularly as compared to die casting or stamping dies, adds not only initial economy but model-change versatility as well.

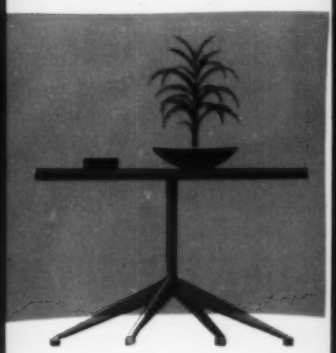
And for the brilliant beauty of any color, these knobs take permanent finish by one-step anodizing—usually at far less cost than chrome plating or similar plated surfaces. Aluminum offers still more useful properties, such as light weight with high strength, corrosion resistance, non-sparking and non-magnetic qualities.

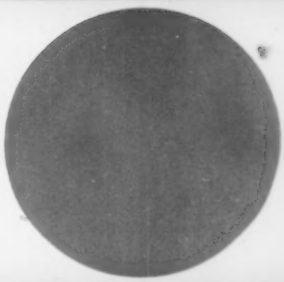
If you would like design details for the parts shown here, complete with cost and production data, please send in the coupon below.

(Kaiser Aluminum does not manufacture screw machine parts, but does offer technical assistance to parts suppliers throughout the country. Contact your local screw machine products manufacturer for further information and quotations on specific parts in aluminum.)

KAISER ALUMINUM

THE BRIGHT STAR OF METALS





☐ PLEASE CALL
☐ PLEASE TELEPHONE

☐ Please send booklet showing design details and cost-production data for parts illustrated in ad.

NAME

COMPANY

ADDRESS

CITY STATE

MAIL TO | Advertising Dept. SM-945
KAISER ALUMINUM & CHEMICAL SALES, INC.
919 N. Michigan Ave., Chicago 11, Illinois

Show us how we may best serve you . . .

from contact shoe beams . . . to ship fenders . . .

GAMBLE solves problems with WOOD!

Contact shoe beams on subway cars hold the apparatus for picking up power from the third rail. The problem: could wood (with its obvious advantages) hold the required dimensional tolerances and provide the necessary dielectric strength? The answer: yes, in the form of a laminated hard maple beam engineered by Gamble Brothers.

The "ship fender" problem was different. Who in the world had the wood-engineering knowledge and physical plant to produce the "king-size" wood laminations? The answer again: Gamble Brothers.

Design problems like these are "all in a day's work" to the wood engineers at Gamble Brothers —a unique organization designing and building a wider variety of wood products than any other U. S. woodworking company. Today they're working on projects in three principal areas: (1) improvement of present wood products (2) development of new wood products (3) product development in combinations of wood and other materials.

Why not present *your* design or component problem to Gamble Brothers? WOOD may be the answer!

FREE booklet illustrates GAMBLE services

This 28-page booklet describes Gamble facilities and services in detail. Includes many photographs of unusual products designed, tested and perfected by Gamble Brothers. Write for your copy today! Gamble Brothers, Inc., 4619 Allmond Ave. Louisville, Ky.

If the problem involves wood, Gamble can help!

GAMBLE BROTHERS GB GUARANTEED BOND

GAMBLE BROTHERS, INC.

4619 Allmond Avenue, Louisville, Kentucky

Circle 456 on Page 19

Another exclusive K&E *development...*

With new PHOTACT® Polyester Films you can make second originals—USING ORDINARY PAPER DEVELOPER

Available in 3 types:
PHOTACT Polyester Film, Contact — 409
PHOTACT Polyester Film, Direct Positive — 411
PHOTACT Polyester Film, Projection — 419
... all three with excellent drafting surface on both sides.

Now, for the first time, you can make photographic second originals *on film* without the fuss and bother of using special, short-lived, expensive developers. With new PHOTACT Polyester Films your regular paper developer does the job perfectly. Think what that means in terms of lower inventory – less cost – simpler operation.

With these new films you get all these other advantages...

... **Blacker blacks,** because PHOTACT film has a higher silver concentration than comparable film.

... **Durability,** wrinkle-proof – you can actually crumple a drawing on new PHOTACT Polyester Film into a ball, smooth it out, and still make a perfect reproduction.

... **Won't yellow** with age – or from repeated trips through the machine.

... **Quick drying** because these films are virtually waterproof.

... **Faster prints** due to greater transparency.

... **Better than original copy** – reproducibles from old yellowed drawings drop out stains, creases – strengthen detail.

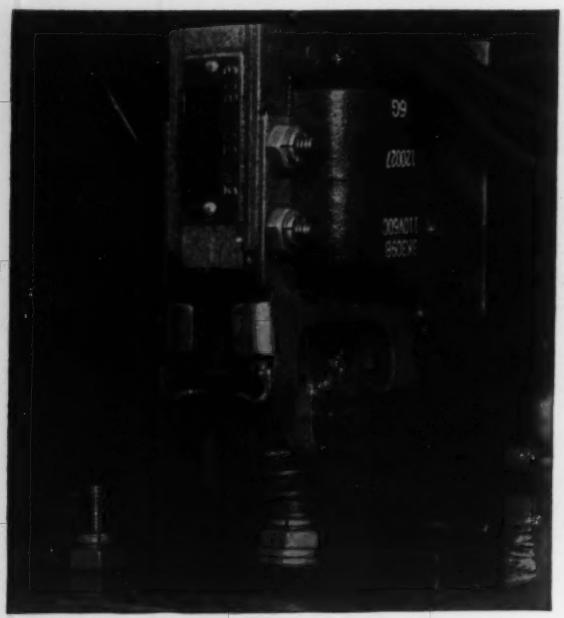
These exceptional new films are part of a complete line by K&E – specialists in reproduction films, papers and cloths. See them now at your K&E dealer's. Or send in the coupon below for free samples and literature.

KEUFFEL & ESSER CO. Dept. MD-2 Hoboken, N. J.
Send me free samples and literature on new PHOTACT Polyester Films:
☐ Contact-409 ☐ Direct Positive-411 ☐ Projection-419

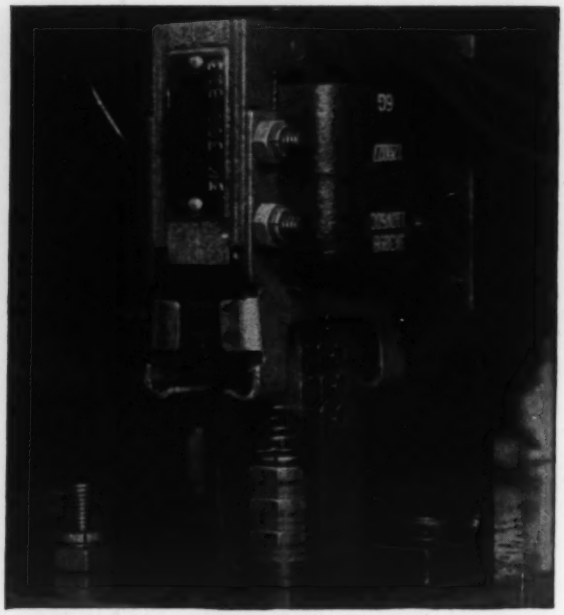
Name & Title: _____

Company & Address: _____

_____ 1425

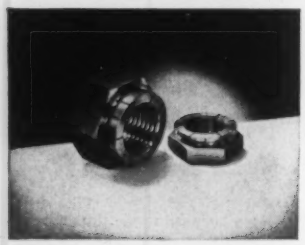


Both regular and thin height FLEXLOC nuts are used to fasten this solenoid valve assembly on a 15,000-lb.-capacity fatigue testing machine. Valve monitors the oil supply to a control cylinder which maintains a constant load on the test specimen.



Stroboscopic photo shows action of solenoid in opening oil supply valve. Unit is capable of speeds up to 60 cycles/sec., chatters hard whenever a test specimen breaks. Despite impact and vibration, the FLEXLOC nuts never require retightening.

FLEXLOC self-locking nuts give your products greater reliability under impact, shock, vibration



Repeated shock, pounding of heavy machinery, high-speed oscillation—nothing will loosen a FLEXLOC self-locking nut. FLEXLOCs help give your assemblies the increased reliability demanded by today's higher operating temperatures, faster speeds, and greater dynamic stresses.

FLEXLOCs are available in either regular height or thin height configurations, the latter being designed for applications where space and weight savings are vital. Both are 1-piece, self-locking units requiring no auxiliary locking elements—no lockwashers, jam nuts or cotter pins. There is nothing extra to put together, come apart or get lost . . . and no nonmetallic inserts to waste head space or weaken the structure of the nut. With a FLEXLOC, every thread, including those in the locking section, carries its full share of the tensile load.

Because they require no separate locking devices, FLEXLOC self-locking nuts facilitate design and specification, simplify inventory and handling, reduce assembly time and costs. They also save on maintenance, because they are readily removed and can be reused many times with no effect on the reliability of their locking action.

Your authorized SPS distributor carries FLEXLOC self-locking nuts—regular and thin height—in all standard sizes, materials and finishes. Flexloc Locknut Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

HIGH RELIABILITY

SPS research is continually developing fasteners with higher standards of predictable performance. By installing SPS high-reliability fasteners in your assemblies, you increase overall product reliability.

For more information on the full meaning of reliability, write for a copy of the new SPS booklet "High Reliability."

We also manufacture precision titanium fasteners / *write for free booklet*

SPS **Jenkintown • Pennsylvania**

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

LOOK!

LOGAN HAS IT!

RIGHT PRICE
TOP QUALITY
PEAK PERFORMANCE

in hydraulic power devices

LOGANSPORT MACHINE CO., INC.
811 CENTER AVENUE, LOGANSPORT, INDIANA

PLEASE SEND COPY OF CATALOG:

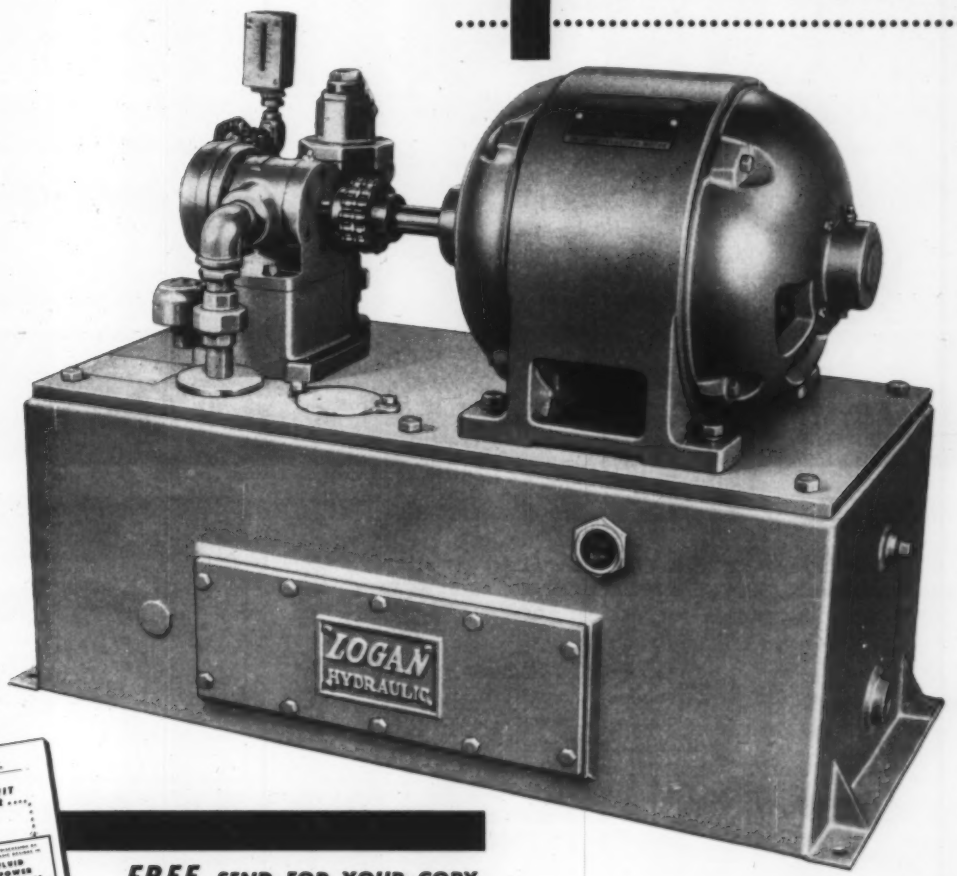
- ☐ 100-1 AIR CYLINDERS
- ☐ 100-2 MILL-TYPE AIR CYLS.
- ☐ 100-3 AIR-DRAULIC CYLS.
- ☐ 100-4 AIR VALVES
- ☐ 100-5 LOGANSQUARE CYLINDERS
- ☐ 100-6 ULTRAMATION CYLINDERS
- ☐ 300-2 PRESSES
- ☐ FACTS OF LIFE
- ☐ 200-1 HYD. POWER UNITS
- ☐ 200-2 ROTOCAST HYD. CYLS.
- ☐ 200-3 750 SERIES HYD. CYLS.
- ☐ 200-4 AND 200-7 HYD. VALVES
- ☐ 200-6 SUPER-MATIC CYLS.
- ☐ 300-1 CHUCKS
- ☐ ABC BOOKLET
- ☐ CIRCUIT RIDER

TO:

NAME_____ TITLE_____

COMPANY _____

ADDRESS _____



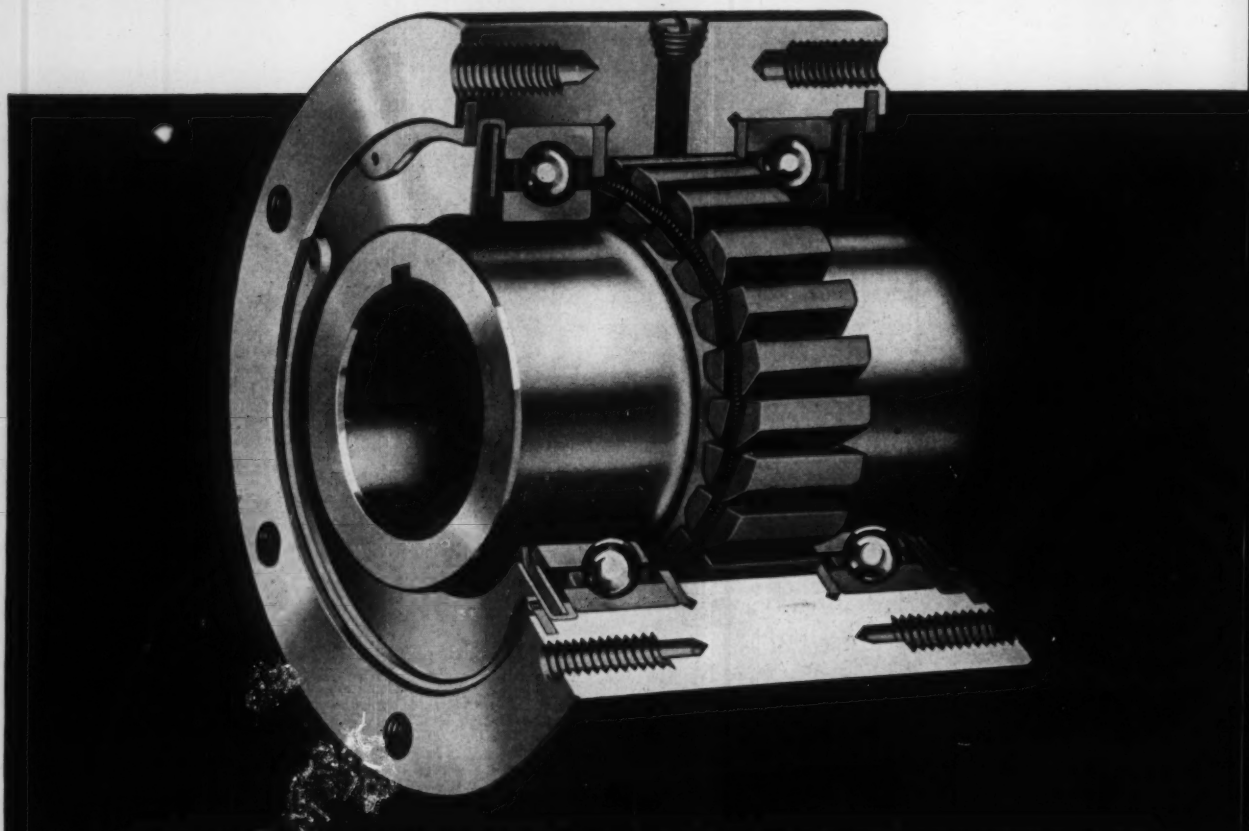
ILLUSTRATED—LOGAN MODEL 6031
HYDRAULIC POWER UNIT

FREE **SEND FOR YOUR COPY OF THE LOGAN "CIRCUIT RIDER"**

A 32-page manual on fluid power circuits (fifth edition) completely revised to present current engineering trends.

MEMBERS: Natl. Mach. Tool Builders' Assn.; Natl. Fluid Power Assn.

The OVER-RUNNING CLUTCH With



OVER-RUNNING · INDEXING
BACKSTOPPING

STANDARD CLUTCHES FOR ORIGINAL EQUIPMENT NEEDS

Formsprag Clutches are used throughout industry, from business machines to aircraft, in bore sizes from ¼" to 12". Several informative bulletins available, including: "Design Considerations for High-Speed Over-running Clutches," "Ten Design Ideas", "Seven Ways to Reduce Space and Costs", plus the complete Formsprag catalog. Write for any one or all.

HERE'S

The Formsprag clutch consists of a full complement of shaped sprags, or wedges, located between concentric inner and outer races. Power is transmitted from one race to the other by the wedging action of the sprags. Each sprag is so shaped that dimension AA is greater than BB. Rotation of one race in the "driving" direction causes the sprags to wedge, transmitting torque in full from one race to the other.

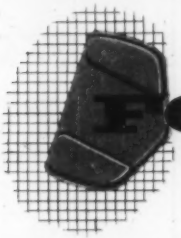
Greatest Torque
Per Inch – Per Ounce

Modern power transmission design demands the utmost torque capacity in an absolute minimum of space. That's why designers in every field specify Formsprag clutches . . . the *modern* way to transmit power on over-running, back-stopping and indexing applications.

Along with highest possible torque capacity for its size and weight, every Formsprag clutch offers such additional benefits as internal simplicity (just four basic parts), no measurable backlash, light weight, compactness, extreme precision and long, trouble-free life. Formsprag's exclusive, patented principle is unlimited in application, yet this full-complement sprag type clutch is extremely simple in design and operation.

There is a size and model Formsprag clutch for every application. Standard models include sleeve bearing, ball bearing, miniature, and large bore backstop types. These are shown in the current Formsprag catalog, complete with specifications, performance data and design suggestions. Ask your Formsprag distributor, or write direct for your copy. For special applications, Formsprag engineers will recommend a modified standard or design a special. Send details of your requirements.

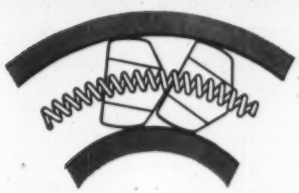
FORMSPRAG COMPANY
23603 Hoover Road, Dept. 100
Warren (Detroit), Michigan
In Canada: Renold Chains Canada, Limited
In United Kingdom: Renold Chains, Limited
Distributors in Principal Cities



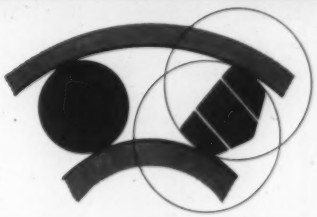
FORMSPRAG CLUTCHES

World's Largest Exclusive Manufacturer of Over-running Clutches

HOW IT WORKS

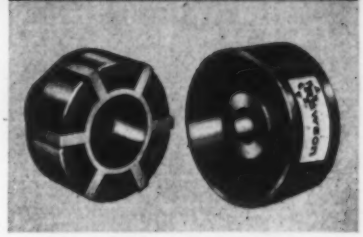


An expanding coil spring keeps the sprags in light contact with both inner and outer races. There is thus no lost motion, the driving torque being instantaneously transmitted between races. The Formsprag Clutch is so designed that it will transmit a greater torque in relation to its size and weight, than any other comparable type of clutch . . . specify Formsprag on over-running, back-stopping and indexing applications.

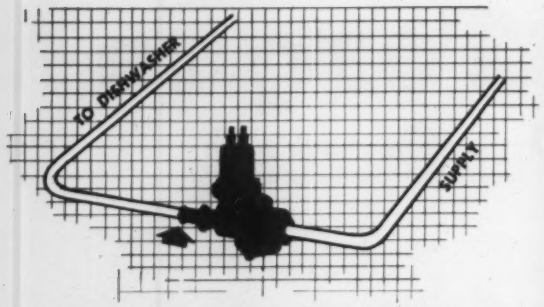


Forcing a ball or roller into a curved, wedged space is an old over-running clutch principle. The sprag is, in effect, a "roller" of increased diameter with greater contact surface in a given annular space. Formsprag Clutches engage at constantly changing contact points. Clutch life is prolonged and backlash eliminated. Also, with the inclined surfaces discarded, more sprags can be inserted to increase torque capacity.

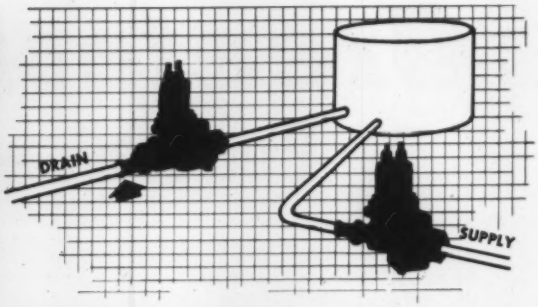
FOR NO-LOAD STARTS



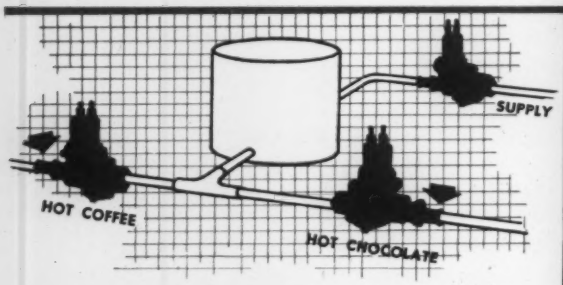
Specify Rawson Automatic Centrifugal Clutches and Clutch Couplings. They protect the prime mover, eliminate need for costly reduced voltage starting equipment, permit use of less expensive smaller motors to start high inertia loads. Completely automatic and entirely mechanical in operation. Rawson clutches provide full overload protection, never need adjustment. Write for the new Rawson Clutch Catalog now.



Hot water enters a dishwasher several times during its wash-rinse cycle. The control? Detroit Controls' S-25 Solenoid valve.



An automatic water softener recharges itself. The S-25 valve and a timer simplifies the regeneration process.

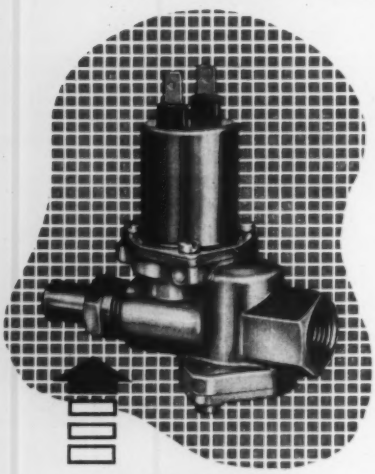


Put a dime in a vending machine. You get your choice of hot coffee or hot chocolate. There's an S-25 controlling the hot water to each—still another controlling the master supply entering the machine.

IT'S YOUR TURN! Doodle your own piping arrangement here. It's dollars to doughnuts that if you have a varying water flow control problem, the S-25 will help you do a better job.

NEW DETROIT SOLENOID
GIVES CONSTANT WATER FLOW

from 1/4 to 6 gpm—2-1/2 to 200 psi—up to 180°F
(Up to 200° For Special Applications)



FLOW CONTROL DEVICE IS LOCATED HERE.

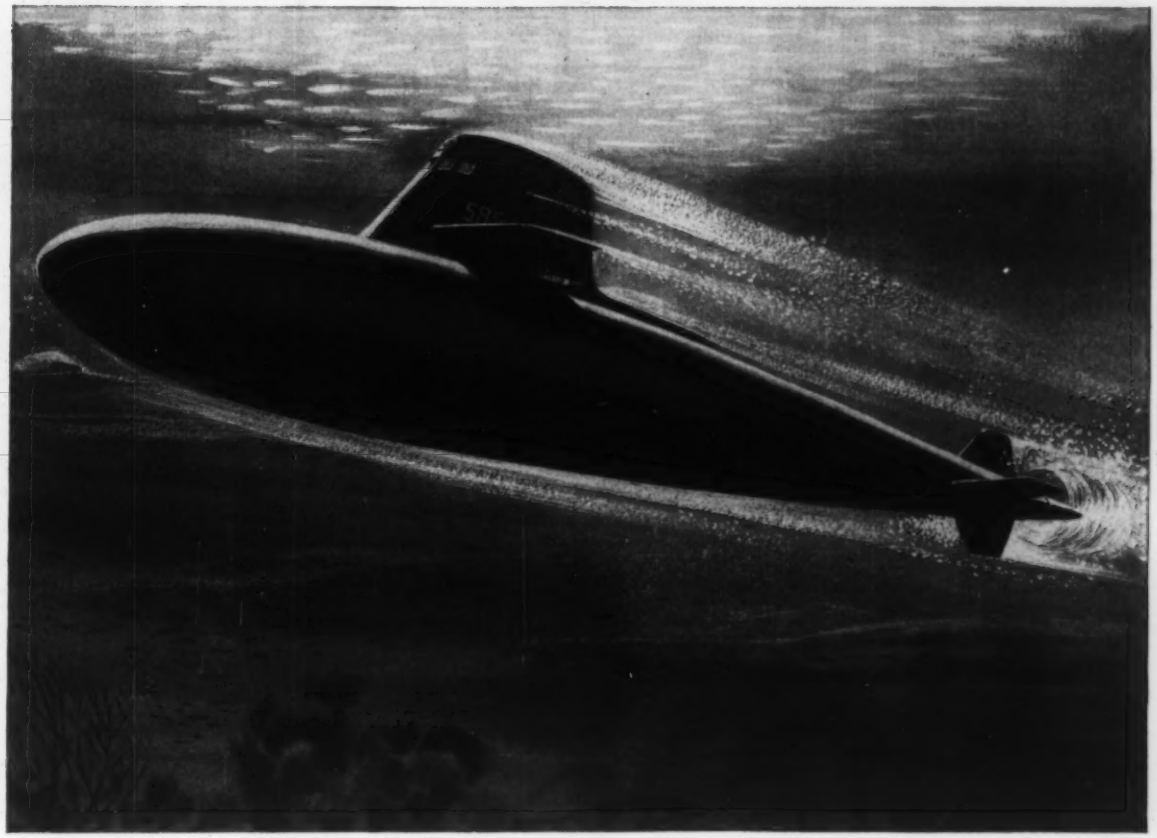
Here's a new valve that will positively open — positively close — time after time after time. Detroit has designed it with flexibility in mind. For example, the flow control device in the outlet connection assures accurate delivery of water quantity regardless of varying supply pressures. It also is available with any of three different connections: pipe, tubing or hose. The S-25's unique construction permits accurate volume control when mounted in any position. There is a wide variety of brackets available. It has a large, integral, easy-to-get-at, easy-to-clean strainer and features waterproof, interchangeable coils for all standard AC voltages. Available with top or side spade terminals or pigtails. It's listed by the Underwriters' Laboratories.

* * *

We know of the three applications above and we'd like to know about yours. Sketch where this valve could fit into your system. Mail it to us and we'll shoot a quote right back to you. Or if you wish, we'll send a Detroit representative out right away. Just write to Detroit Controls Division of American-Standard, 5900 Trumbull Ave., Detroit 8, Michigan.

American-Standard and Standard ® are trademarks of American Radiator & Standard Sanitary Corporation.

American-Standard
DETROIT CONTROLS DIVISION



Sandusky cylinders help the Skipjack CRUISE, DIVE, STEER, BREATHE and FIGHT!

Centrifugally cast cylinders by Sandusky play vital roles in the U. S. Navy's newest atomic-powered submarine, No. 585 *Skipjack*, as components of the nuclear propulsion system, the steering and diving systems, the torpedo firing mechanism, and radar and induction mast assemblies.

The *Skipjack* is the prototype of a new series of seven submarines all with blimp-shaped hulls for greater underwater speed. Her design and materials specifications were laid down by the U. S. Navy and her builder, The Electric Boat Division of General Dynamics Corporation, who chose Sandusky Centrifugal Castings to do more than ten jobs in structural, mechanical, pneumatic, and hydraulic applications.

All of these components – centrifugally cast of heat and corrosion-resistant stainless steels, high-strength carbon steels, Monels, and bronzes–provided the *Skipjack's* designers with the required mechanical and physical properties at the lowest cost.

You, too, may find a ready solution to your cylindrical problems in Sandusky Centrifugal Castings. We invite your inquiries.

Sandusky cylinders are cast and machined in this range:

From 7" to 54" O.D.

Up to 33 ft. in length (depending on diameter)

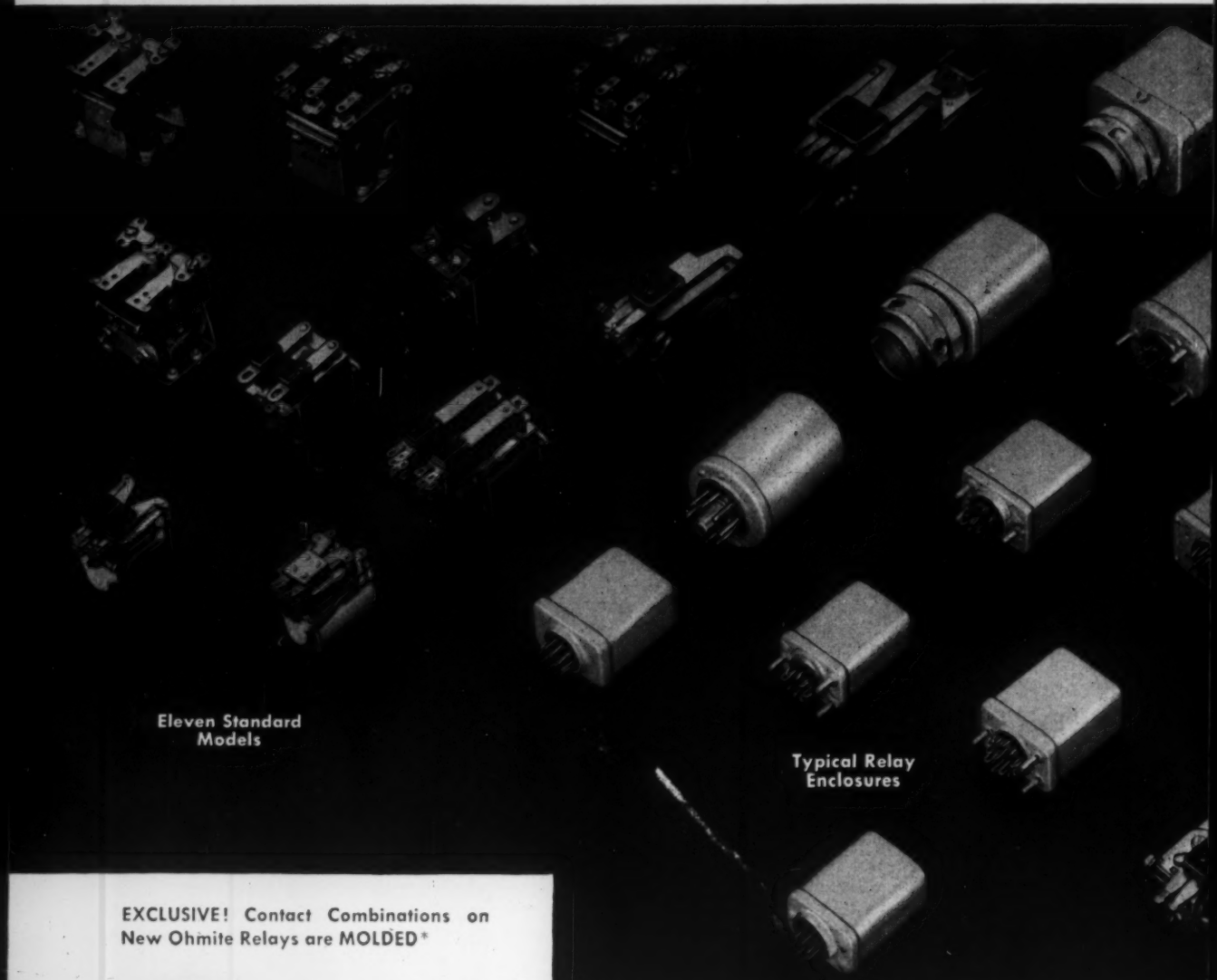
Light or heavy-walled

In a variety of alloys including Stainless, Carbon, Low Alloy Steels. A full range of Copper-Base, Nickel-Base Alloys.

SANDUSKY CENTRIFUGAL CASTINGS
FOUNDRY & MACHINE CO.
SANDUSKY, OHIO

Circle 462 on Page 19

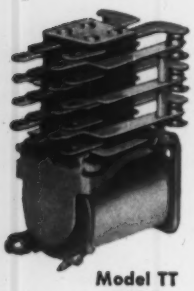
specify OHMITE®



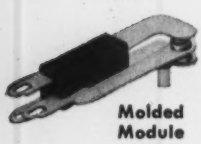
Eleven Standard Models

Typical Relay Enclosures

EXCLUSIVE! Contact Combinations on New Ohmite Relays are MOLDED*



Model TT 6PDT



Molded Module TT

Permanence and ease of adjustment of the individual contact springs are the result of a revolutionary, new innovation found in two new Ohmite Relays—Models TT and TS. This innovation is the unique "Molded Module"* contact spring construction. The "module" is a standard, single-pole, double-throw spring combination molded into a single compact assembly. As many as six modules can be incorporated into a single relay.

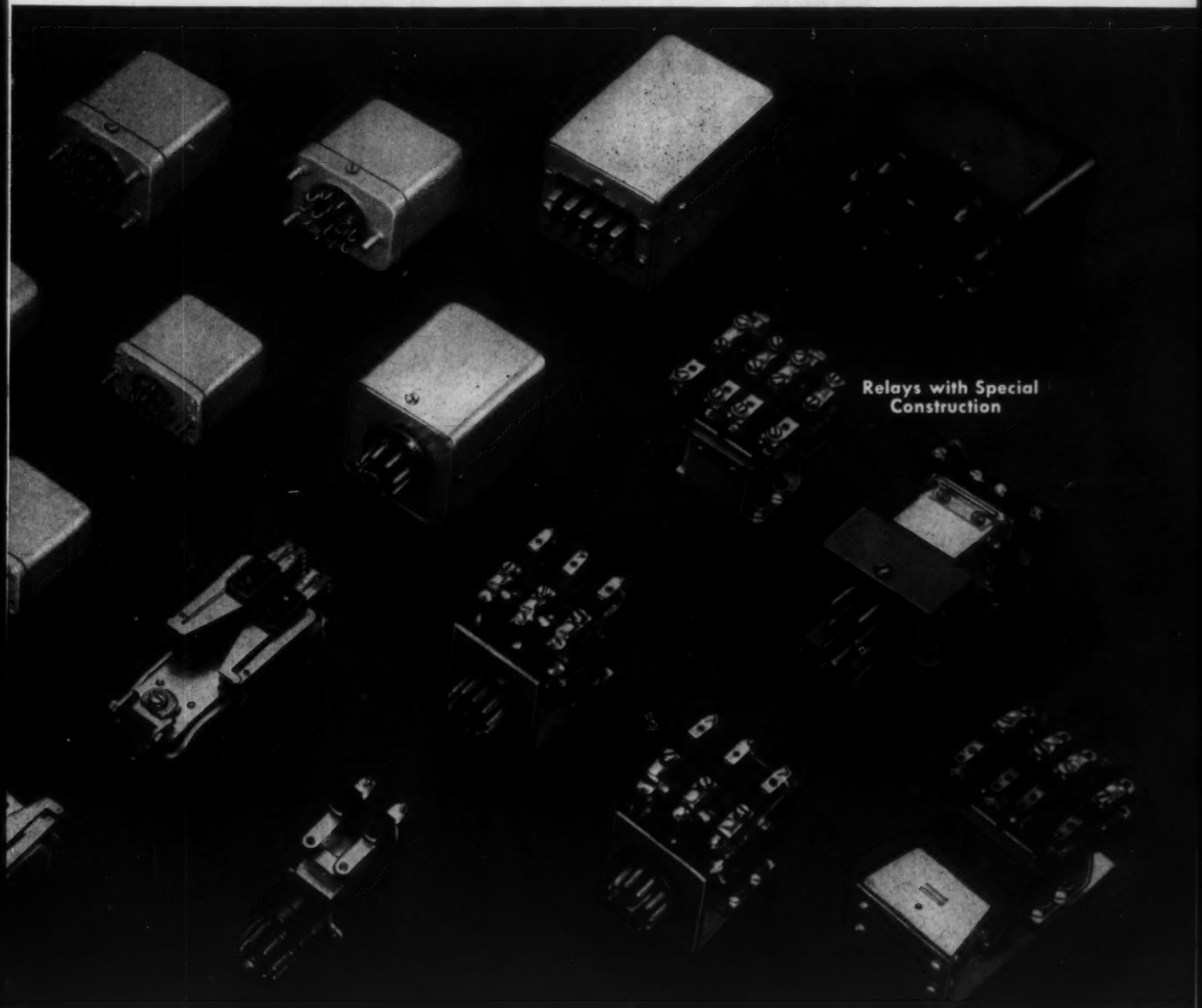
**(*Pat. Applied For*)*

QUALITY CONSTRUCTION— All Ohmite relays embody the same meticulous engineering, strict quality control, and generous use of high-quality materials which have made Ohmite components the standard of the industry. Parts are plated where necessary for corrosion resistance. Springs are of nickel-silver or phosphor-bronze. Contacts are fine silver. Special contact materials, such as silver, tungsten, palladium, or gold alloy, can be supplied. Protection against humidity and moisture is paramount and is accomplished in layer-wound coils, through complete sealing with cellulose-acetate. Relays are available in a wide range of coil operating voltages and contact combinations in both AC and DC types.

65 TYPES IN FOUR STOCK MODELS— For fast service, four popular models in the Ohmite relay line are carried in stock in 65 types at the factory, and by Ohmite Distributors from coast to coast.

HERMETICALLY SEALED AND DUST-TIGHT RELAYS— You can specify many of the basic Ohmite relays in nonremovable, hermetically sealed enclosures for applications requiring complete relay protection.

Relays for Reliability



These high-quality relays are sealed in seamless steel enclosures which are exhausted and filled with dry, inert gas under control of Ohmite engineers. Ohmite hermetically sealed relays are available with either plug-in or solder terminals. Relays are also made with nonremovable dust-tight covers and removable dust covers.

RELAYS WITH SPECIAL CONSTRUCTION—Ohmite relays are available with special terminals or special construction, such as relays with push-on or screw terminals, relays with binding-post terminals. Where quantities warrant, Ohmite will manufacture relays made to your specifications. Ohmite can furnish not only special terminals, special contact combinations, contact materials, and coils but also special enclosures, connectors, impregnation, or frames. Ohmite relays can be engineered to meet your special pull-in, drop-out, or time-delay requirements.

For your special or unusual relay applications, let Ohmite's experienced engineers help you work out the best solution.

Circle 463 on Page 19

Write on company letterhead for Catalog and Engineering Manual 58.

OHMITE®

MANUFACTURING COMPANY

3618 Howard Street, Skokie, Illinois

RESISTORS RELAYS TAP SWITCHES
RHEOSTATS TANTALUM CAPACITORS
R.F. CHOKES VARIABLE TRANSFORMERS
DIODES

PUROLATOR FILTERS FOR THE PROTECTION OF HYDRAULIC CIRCUITS

G-200M Aircraft Restrictor Filter two-way for hydraulic oil systems metal element

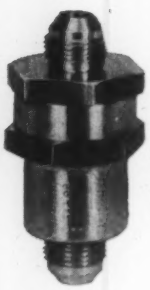
PR 301 ½ GPM line type hydraulic oil filter Micronic element

PR 362 3 CFM in-line vent type Micronic element

G 200 series in-line two-way restrictor filter Metal element, internal connections

PR 312 12 GPM line type filter Micronic element

PR 412-8 12 GPM line type filter Military approval



G-187 3 GPM in-line hydraulic oil filter Metal element

P 32-26 Low pressure, high flow hydraulic oil filter

Effective filtration is essential for optimum performance in hydraulic circuits. To keep a system clean and functioning properly, it is important that the filter be designed specifically to meet the requirements of the job.

Purolator's complete line of filters for hydraulic systems includes models for every set of operating conditions likely to be encountered. A few are shown here; there are many more standard models from which to choose. If your application requires a special filter, Purolator will design and build it. Let Purolator work on your toughest filtration problem.

Filtration For Every Known Fluid

PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey and Toronto, Ontario, Canada

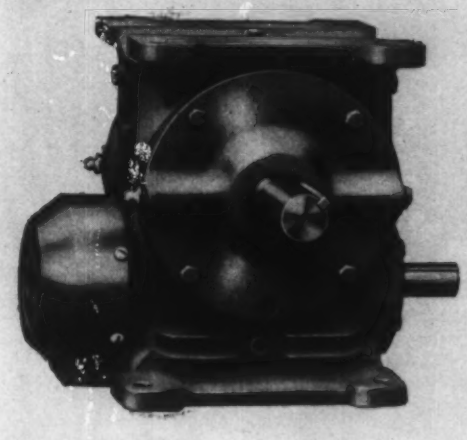
Circle 464 on Page 19

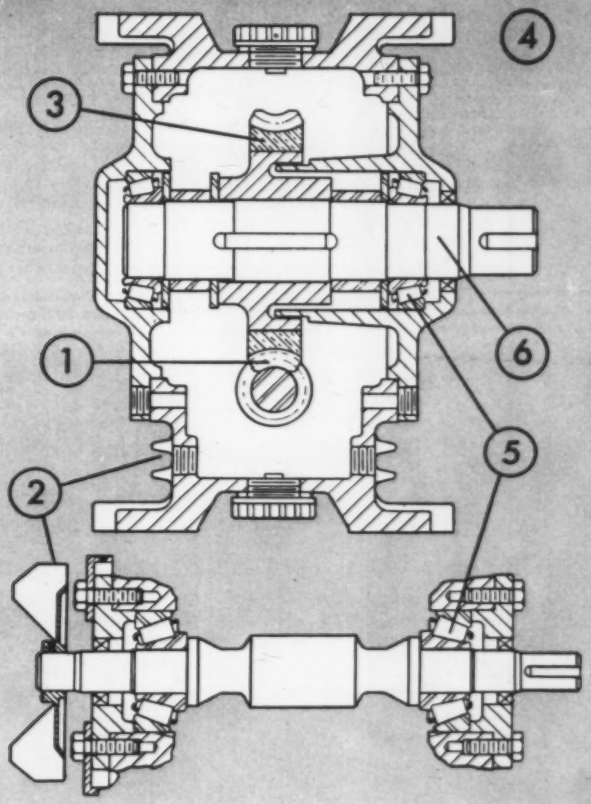
DELROYD

VERSO WORM GEAR SPEED REDUCERS

a new standard in worm gear design

smaller space and more horsepower per dollar





Make this value analysis NOW!

1. Involute helicoid thread form has highest load capacity of any type of worm gear.

2. Fan cooling and ribbed construction give maximum effect of heat dissipation.

3. Centrifugally cast bronze dished gear—dry well construction.

4. Unit may be mounted in any position. Alternate mounting surfaces.

5. Tapered roller bearings used throughout—provide maximum load capacity.

6. Heat treated alloy steel gear shaft with bearing and sealing diameters provide a strength of 185% of an untreated shaft of the same diameter.

Send for Catalog No. 5018

DE LAVAL *Steam Turbine Company*

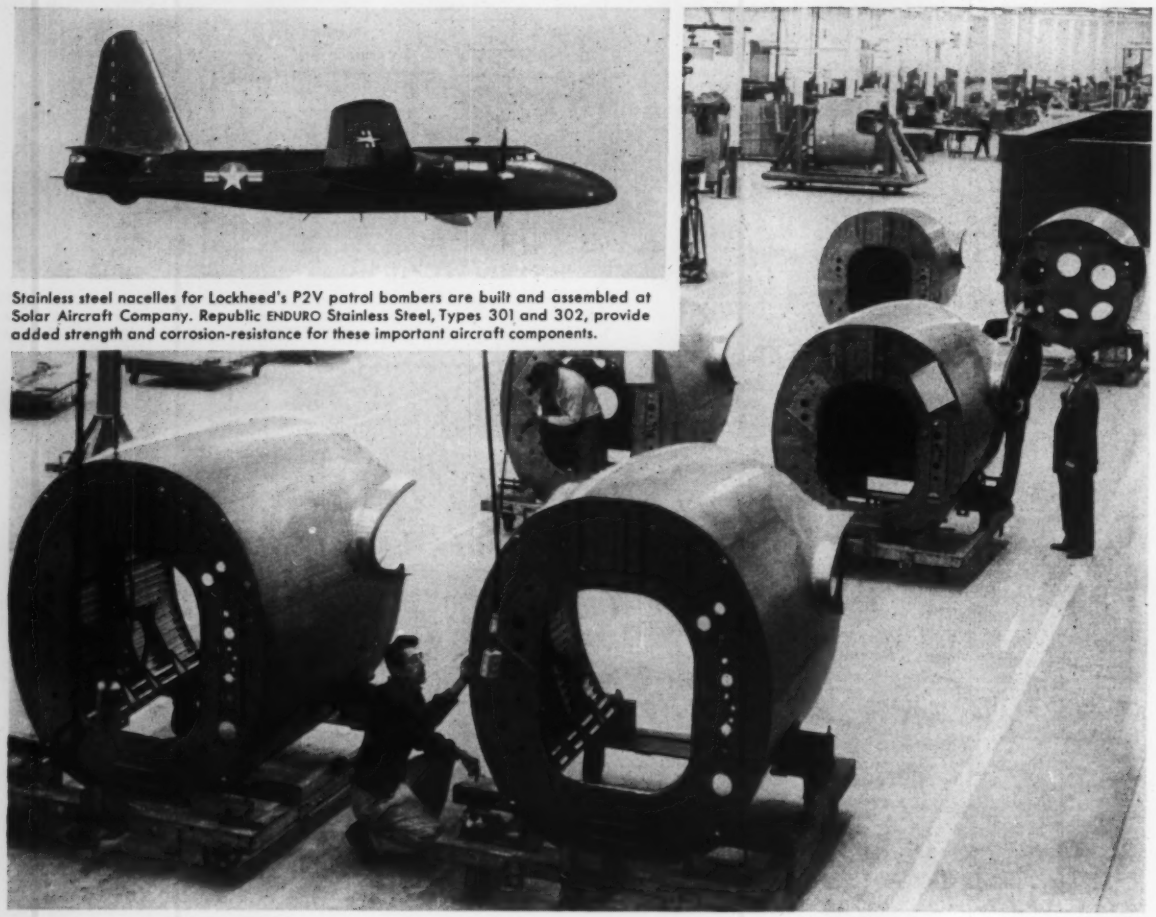
858 Nottingham Way, Trenton 2, New Jersey

DL444

Problem-Solving Products from Republic

Increase Strength, Withstand High Temperatures, Fight Corrosion, Provide Production Economies

Stainless steel nacelles for Lockheed's P2V patrol bombers are built and assembled at Solar Aircraft Company. Republic ENDURO Stainless Steel, Types 301 and 302, provide added strength and corrosion-resistance for these important aircraft components.



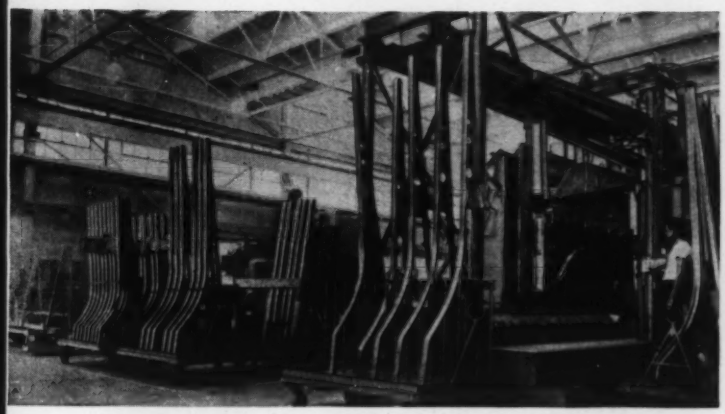
REPUBLIC ENDURO® STAINLESS STEEL HELPS SOLVE strength, heat, and corrosion problems in engine nacelles for the Navy's P2V patrol bombers.

Complete nacelles are built by Solar Aircraft Company, San Diego, California, pioneers in stainless steel airframe construction. To date, Solar has manufactured more than 1000 nacelles for Lockheed's P2V program using A.I.S.I. Types 301 and 302 Stainless Steel.

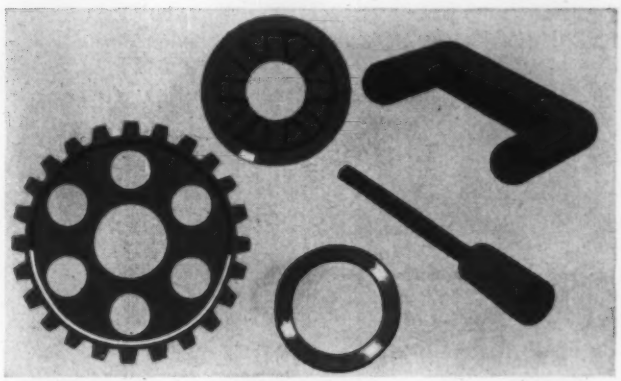
The stainless steel construction of these airframe units offers a number of advantages including greater strength, ability to withstand high temperatures, less maintenance for protection against corrosion and more economical production processes.

Republic ENDURO Stainless Steels, Types 301 and 302, provide needed strength, yet permit the use of lighter gages to save weight. They are highly resistant to atmospheric corrosion, erosion, and oxidation at high temperatures. They are readily formed into desired shapes by the usual commercial methods.

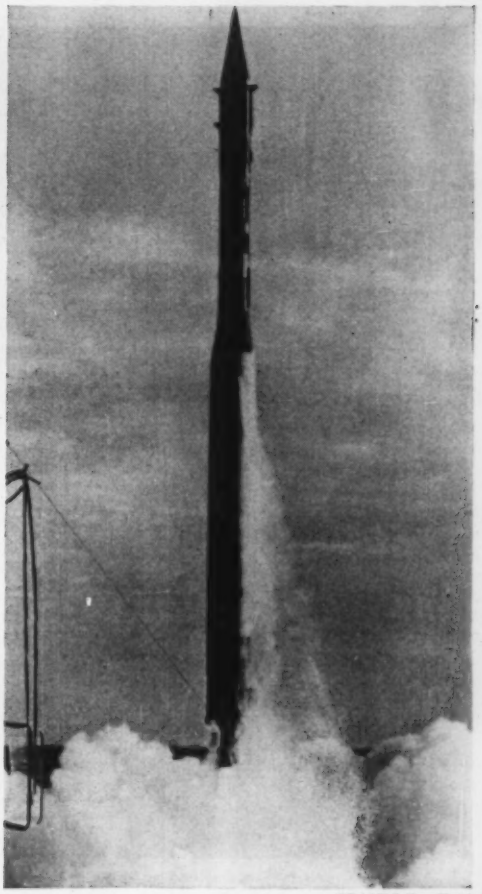
Like Solar, Republic is also a stainless steel pioneer. Republic metallurgists and engineers pioneered the development of these high strength-to-weight, heat-resistant, and corrosion-resistant metals. To help you use them to best advantage, Republic offers you the services of its famed 3-Dimension Metallurgical teams —field, mill, and laboratory metallurgists. The coupon is your invitation to use this confidential and obligation-free service.



ALLOY STEEL WELDMENTS meet high strength, precision requirements in USAF bombers. The weldment technique, developed by Rohr Aircraft Corporation, Chula Vista, California, is currently being used in the manufacture of flap tracks for an Air Force Bomber program. The material used is AMS 6428 Alloy Steel, a type supplied by Republic. This fine steel provides a minimum tensile strength of 180,000 psi in the heat treated condition. Uniform response to heat treatment assures exceptionally good deep hardening characteristics — plus hard-wear-resistant surfaces. Specify Republic Alloy Steel for your parts that must be tough, strong, dependable. Our metallurgists will help you. Send coupon for facts.



REPUBLIC DEVELOPS NEW POWDER for structural, electrical, and electronic part applications. Type MS is a soft, higher purity powder with excellent carbon compatibility. It can be used for comparable strength structural parts at lower cost than obtainable with copper. It is also ideally suited for use in fabricating pole pieces, permanent magnets, cores, armatures, etc. MS Powder can be used to fabricate larger parts on normal pressing equipment. Mail coupon for complete details on physical properties, chemical composition, test evaluations.



(Official U.S. Navy Photo)

TITANIUM FOR WEIGHT REDUCTION in the Navy's Vanguard. Because of its weight saving and high strength factors, titanium is currently being used for many applications in both missiles and aircraft. In missiles and rockets it has almost unlimited applications. Titanium's extremely high corrosion-resistance makes it attractive for tanks to hold acids used in combination with missile fuels. Nitric acid, for example, has negligible effect on titanium. It is practically immune to salt water and sea air corrosion. Republic produces titanium in all commercial forms. Republic metallurgists will help you apply titanium to best advantage. Send coupon for more facts.

REPUBLIC STEEL

World's Widest Range of Standard Steels and Steel Products

REPUBLIC STEEL CORPORATION
DEPT. MD-6127
1441 REPUBLIC BUILDING • CLEVELAND 1, OHIO

Have a metallurgist call.
☐ Stainless Steel ☐ Alloy Steel ☐ Titanium

Send more information on:
☐ Stainless Steel ☐ Alloy Steel
☐ Titanium ☐ MS Powder

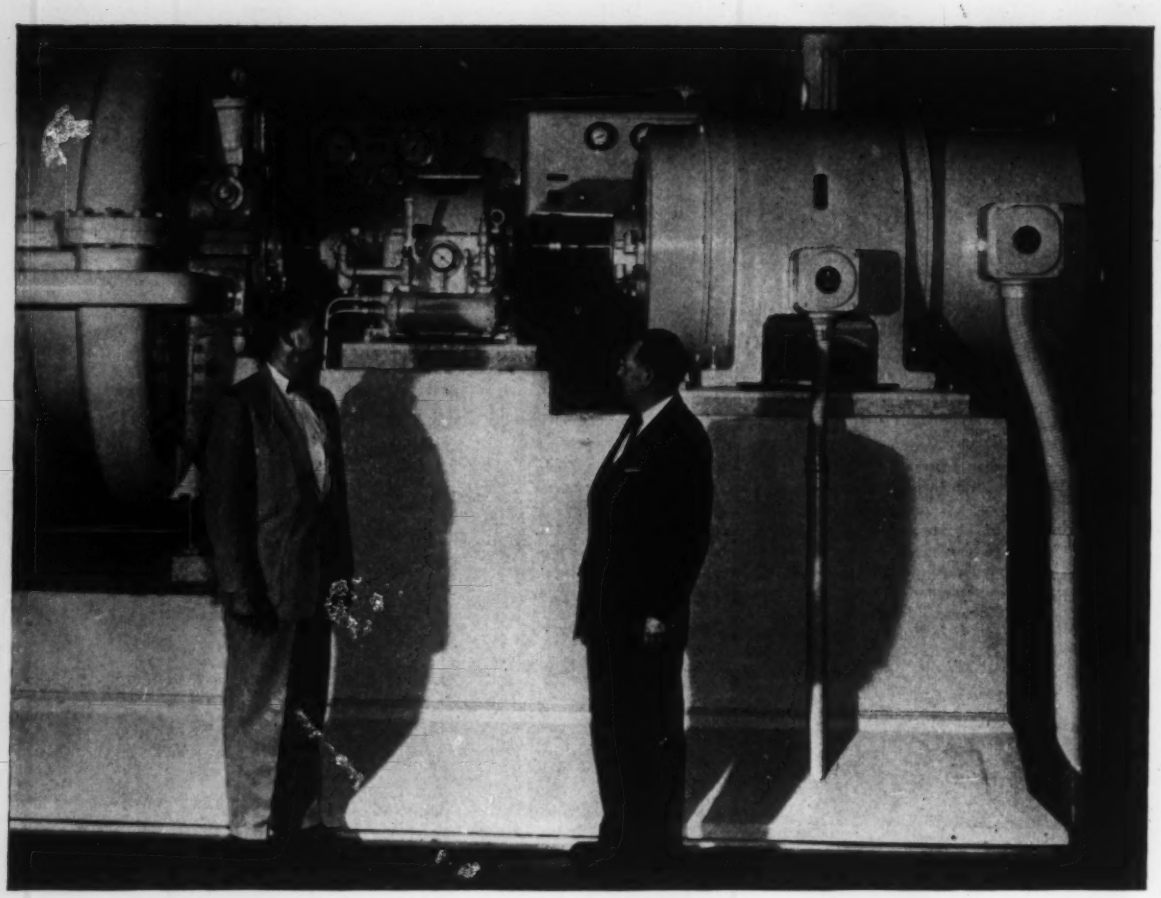
Name_____ Title_____

Company_____

Address_____

City_____ Zone_____ State_____

Circle 465 on Page 19



One of two Fairbanks-Morse 4160 volt, 700 hp. slip ring motors which power Carrier refrigeration compressors.

8-speed climate with F-M motors!

Flexible control of new air conditioning system saves power and maintenance for Union Oil Center

Through a new Carrier dual-duct high-velocity system powered by Fairbanks-Morse slip ring motors, the magnificent new Union Oil Center in Los Angeles is ideally air-conditioned at minimum power and maintenance cost.

Providing 8 speeds between 75 and 100 percent of capacity, the two F-M 700 hp. motors make it possible to match operating rpm. of compressors, chillers and condensers to any specific condition. The new Center covers 5 acres, with 1200 employees occupying 426,000 square feet of the office space in a complex of four buildings—an installation requiring the finest in air-conditioning equipment and components.

Fairbanks-Morse offers the distinct advantage of a broad range of alternating and direct current motors, in all types, and in ratings from ½ to 10,000 hp.

For expert assistance in specifying, write Fairbanks, Morse & Co., 600 South Michigan Ave., Chicago 5, Illinois.

New Union Oil Center in Los Angeles.

FAIRBANKS-MORSE

a name worth remembering when you want the BEST

ELECTRIC MOTORS • GENERATORS • PUMPS • SCALES • DIESEL, DUAL FUEL AND GAS ENGINES • LOCOMOTIVES • COMPRESSORS • MAGNETOS • HOME WATER SYSTEMS

Circle 466 on Page 19

Technical data for gasket design and selection

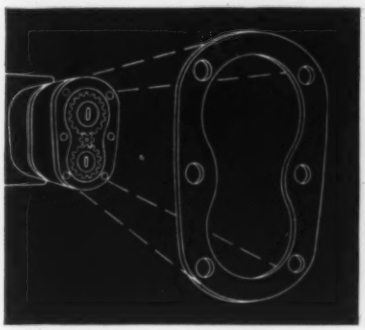
NUMBER TEN

How to be sure of dimensional stability in fiber gaskets

Dimensional stability in fiber gaskets is obviously important in assembly line production, where warped or shrunken gaskets can cause delays.

Although it is sometimes overlooked, this factor is equally important in gaskets sold for replacement purposes. Such gaskets are usually in dealers' stocks for long periods under varying conditions of temperature and humidity. Often they become unusable or fail to give satisfactory service when they are installed.

Shrinkage and warpage of conventional fiber gaskets stem from the fact that their saturant—usually a glue-glycerine solution—is extractable.



Conventional fiber gaskets on this food mixer dried out and leaked. Switch to Armstrong Accopac eliminated this problem.

This extraction can take place in a short time while the gasket is in service or over a relatively longer period if the gasket is in storage.

A maker of food processing equipment found an economical answer to this problem in Accopac N-852—an Armstrong beater-saturated gasket.

N-852 is made with a nitrile-type rubber binder that is non-volatile and non-extractable in any recommended application. Gaskets cut from N-852 are virtually unaffected by variations in temperature and humidity.

If the fiber gaskets you are using lack dimensional stability, or if they warp or get brittle with age, it is likely that N-852 or one of the other compounds in the Armstrong line will be the answer. We will be glad to suggest appropriate materials if you send details of your problem to us.

How to get lasting gasket seals on aluminum flanges at high pressures and temperatures

Where aluminum flanges are used—particularly at temperatures of 300° F. or above—some new problems in gasket engineering are encountered.

These problems are obviously related to the fact that aluminum's coefficient of expansion is roughly twice that of cast iron or steel.

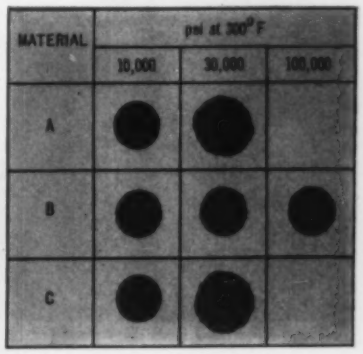
As heat is applied to an aluminum assembly, expansion has the effect of substantially increasing the unit load above that required for sealing at room temperature. This higher load

Test jig on Baldwin-Southwark Universal Tester determines tendency of gasket samples to crush and extrude under high compression loads.

usually causes conventional fiber materials to crush and extrude, resulting in serious loss of bolt torque.

As the assembly cools to room temperature or below, the contraction of the aluminum often is greater than the gasket material can compensate for, and the result can be leakage.

Engineering studies on problems peculiar to aluminum flanges have been carried on at the Armstrong Research and Development Center for more than a year. These studies show that conventional fiber materials have a marked tendency to crush and extrude under heat and pressure. In fact, for many applications, these materials offer practically no safety factor.



Test samples of conventional fiber materials (A and C) show extensive crushing at 30,000 psi. Accopac AN-890 (B) is not affected at 100,000 psi.

With the use of aluminum growing rapidly—and in applications that impose increasingly severe service conditions on the gasket—the need for a new material becomes obvious.

As a result, Armstrong research has developed a new beater-saturated asbestos gasket material—Accopac AN-890. This new product resists crushing and extrusion even under pressures of 100,000 psi at temperatures up to 350° F. It is already being used in a variety of critical aluminum flange applications.

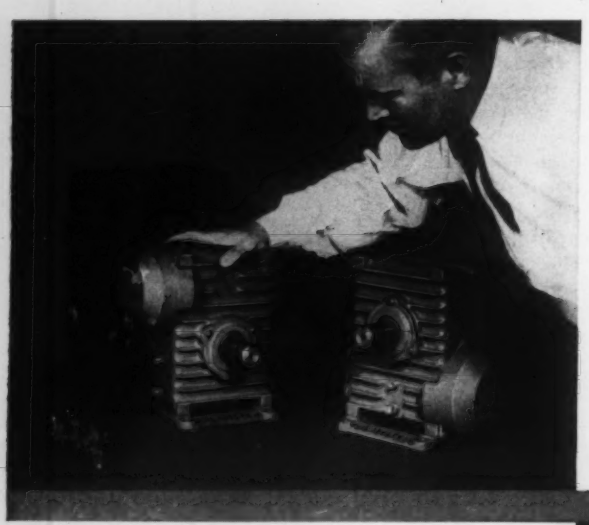
If you are now working—or planning to work—with aluminum flanges, our experience may be helpful. We will be glad to make suggestions if you will submit details of your problem to us. Write Armstrong Cork Company, Industrial Division, 7102 Dean Street, Lancaster, Penna.

Armstrong GASKET MATERIALS

. . . used wherever performance counts

Circle 467 on Page 19

new high capacity fan cooled reducers take up 50% less space



LOOK AT THE SPACE YOU SAVE!

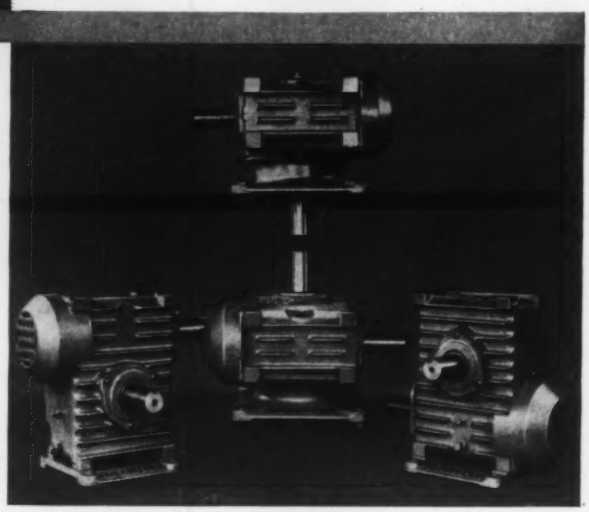
Think what this can mean to your products! You can make important savings in space and weight . . . in the neighborhood of 50% . . . depending upon output torque requirements. Or, you can design for heavier loads . . . up to 80% . . . without adding an ounce of weight to your product. You get more horsepower per dollar!

This new line of Philadelphia Fan cooled Worm Gear Reducers is available in 3, 3½ and 4″ center distances for ratios from 5 1/6:1 to 60:1. Fan cooling, sturdy finned housings, improved tooth forms, precision ground alloy steel worms and special high strength bronze gears all combine to give you a drive that will handle heavier loads in less space.

STANDARD STOCK PARTS SIMPLIFY SELECTION.

These new fan cooled units have a degree of simplicity and flexibility never before available. Standardized housings, fans, gearing and mounting bases permit you to select any drive arrangement you need . . . permit us to give you prompt delivery from stock.

They simplify your design problems too. For Example: horizontal units can be furnished without mounting bases. Housings can be designed as an integral part of your product.



For more information . . . horsepower ratings . . . dimensions . . . construction details . . . write for your copy of Bulletin WG-583.

PHILADELPHIA GEAR CORPORATION

Erie Avenue and G Street • Philadelphia 34, Pennsylvania

philadelphia gear drives

Offices in all Principal Cities • Virginia Gear & Machine Corp., Lynchburg, Va.

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID MIXERS • FLEXIBLE COUPLINGS

Circle 468 on Page 19

Circle 469 on Page 19→

Now ALLEN-BRADLEY OILTIGHT PRESSURE SWITCHES

Bulletin 836 Type T

Both operating pressure and differential are adjustable on these new A-B oiltight pressure switches. Operating pressure is externally adjustable, and setting shows on calibrated scale. A trip indicator shows operating point.

For machine tool hydraulic systems—operating at pressures up to 5,000 psi

Especially designed for heavy duty industrial applications, these new Allen-Bradley oiltight high pressure switches assure long, trouble free life. The attractive die-cast aluminum enclosure is completely sealed to exclude oil and water. The snap-action switch mechanism maintains its high contact pressure to the point of switchover—no matter how slowly it is approached. Contact chatter is eliminated—trouble free contact life is increased. The contact block has two isolated circuits with one N.O. and one N.C. set of contacts.

Send for complete information on this newest addition to Allen-Bradley's wide line of *quality* pilot controls.

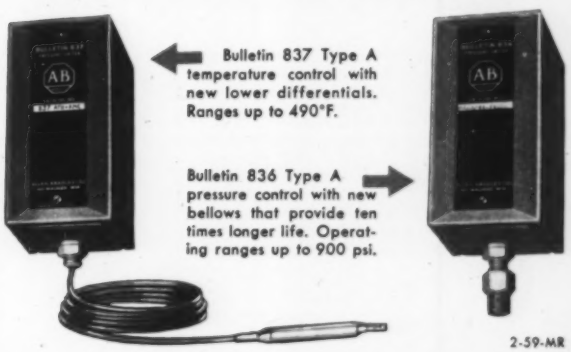
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY
MOTOR CONTROL
QUALITY

A-B QUALITY

Internal view of piston design used on units for systems above 500 psi. Bellows type construction is used up to 500 psi.

Also...A New Line of Pressure and Temperature Controls with Lower Differentials



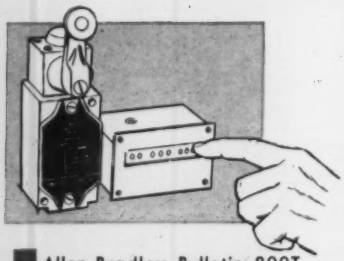
Bulletin 837 Type A temperature control with new lower differentials. Ranges up to 490°F.

Bulletin 836 Type A pressure control with new bellows that provide ten times longer life. Operating ranges up to 900 psi.

2-59-MR

Allen-Bradley is not satisfied until Limit Switch Life runs into

MANY MILLIONS OF OPERATIONS



■ Allen-Bradley Bulletin 800T oiltight limit switches on typical life tests have run many millions of operations. Write for complete information on the Allen-Bradley line of quality limit switches for every industrial application.

Here are some new—and some old—Allen-Bradley oiltight limit switches—all built to give you extra millions of trouble free operations. Their switch bodies and operating heads are both sealed. Oil, dirt, and metal chips cannot enter and foul the contacts or cause sluggish operation of the momentary contact mechanism. Double break, silver alloy contacts never need maintenance. The snap action switch is positive insurance against any reduction of the contact pressure as the "trip point" is approached. This means less chance for chatter and arcing of relays, contactors, or starters operated by the limit switch—and prolonged trouble free contact life for the limit switch itself.

The Allen-Bradley line of limit switches is complete. Illustrated are only a few variations.

Side Push Rod

Top Push Rod with Plastic Window

Adjustable Rod

Adjustable Roller Lever

Roller Lever for Flush Mounting

Neutral Position Momentary Contact Limit Switch. One set of contacts is closed for each direction of operation.

Wobble Stick Type

Fork Lever Type

Side Push Roller

Roller Lever for Manifold Mounting

Side Push Rod Maintained Contact

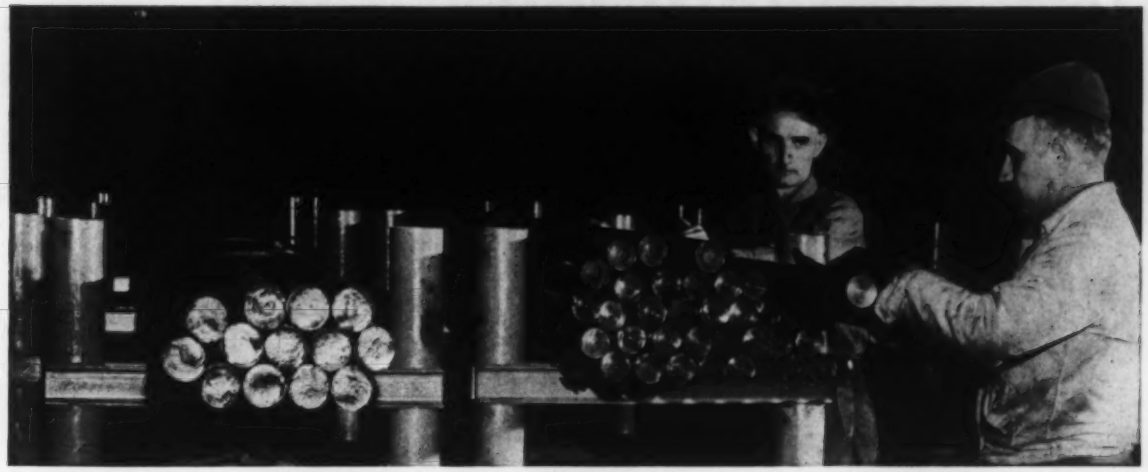
ALLEN-BRADLEY

MOTOR CONTROL

QUALITY

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

Metal users, save money!



simplify materials control... standardize manufacturing processes

by standardizing on two alloy steels... 4340 and 4620

4340 THROUGH-HARDENING—Use AISI 4340 for moderate-to-heavy section parts... to get maximum strength, toughness, reliability. It's readily annealed to facilitate machining... can even be machined as heat treated in many cases. Welds readily with normal precautions. Responds reliably to heat treatment.

4620 CARBURIZING—Use AISI 4620 for all except the very heaviest duty carburized parts. It is the steel least apt to distort in heat treating. Case hardens easily with excellent case toughness. Shows uniform response to treating. You can treat mixed furnace loads . . . eliminate a re-heating cycle . . . *save more money.*

AMERICAN STEEL WAREHOUSE ASS'N.

Easy to Get... Both these steels are carried by Steel Service Centers from coast to coast . . . ready for delivery on a "next door" basis. For a list of these sources, write: 67 Wall St., New York 5, N.Y.

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York 5, N. Y.

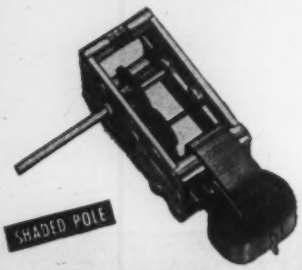
INCO TRADE MARK

New from HOWARD...a Complete

- **UNIVERSAL**
- **SHADED POLE**
- **INDUCTION**

Ratios from 3:1 to 2700:1

Shown on these pages are just a few of Howard's gear motors. Thousands of combinations and ratios are available in universal, shaded pole and induction types. If your product requires gear motors, check today for complete information. Give us details of your application and quantities required and we will be happy to submit samples and quotations or more information on standard types available.



MODEL 300

TYPE: Two Pole Shaded Pole AC—3200 R.P.M.

WIDTH: 2-15/32". LENGTH: 3-7/8".

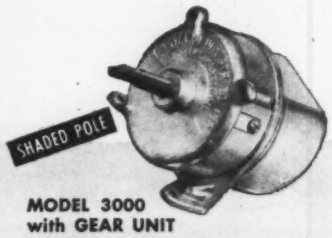
MAXIMUM CONTINUOUS TORQUE OZ. IN. (at 11/16" Stacking Length).
*1 R.P.M. 500 oz. in.
*150 R.P.M. 3.3 oz in.

MAXIMUM INTERMITTENT TORQUE OZ. IN. (at 11/16" Stacking Length).
*1 R.P.M. 750 oz in.
*150 R.P.M. 5 oz. in.

VOLTS: 12 to 115.

BEARINGS: Porous bronze sleeve bearing with oil reservoir.

*Torques at intermittent speeds are inversely proportional to speed.



MODEL 3000 with GEAR UNIT

TYPE: 2 Pole Shaded Pole.

DIAMETER: 3-7/16".

LENGTH: 3-5/8" to 4-1/2".

MAXIMUM CONTINUOUS TORQUE* 1 R.P.M. (at 1-1/2" Stacking Length): 45 in. lbs.

MAXIMUM INTERMITTENT TORQUE* 1 R.P.M. (at 1-1/2" Stacking Length): 70 in. lbs.

BEARINGS: Porous bronze sleeve type with oil reservoir.

*With external fan. Torques at other speeds from 1 to 400 rpm available upon request.

MODEL 2400

TYPE: 4 Pole Induction.

DIAMETER: 2-9/16" square.

LENGTH: 2-3/8" to 3".

SINGLE PHASE CAPACITOR MOTOR:
Maximum Torque oz. in.—1.
Full Load Speed R.P.M.—1150.
Bearings—RBC—Ball. RWC—Sleeve.

TWO PHASE MOTOR:
Maximum Torque oz. in.—1.5.
R.P.M.—1150.
Bearings: RBT—Ball. RWT—Sleeve.

BEARINGS: Porous bronze sleeve type with oil reservoir, or grease sealed ball bearings.

GEAR UNITS: Ratios 6:1 to 3600:1. Spur gears throughout. The high speed pinion is cut on the shaft, assuring accuracy and concentricity, and maximum strength is achieved by supporting the output shaft in large porous bronze bearings.

MODEL 2500

TYPE: 2 or 4 Pole Induction.

DIAMETER: 2-9/16" square.

LENGTH: 1-7/8" to 2-3/8".

SPEED: *1200 to 3600 R.P.M.

H.P.: 1/300 to 1/1400.

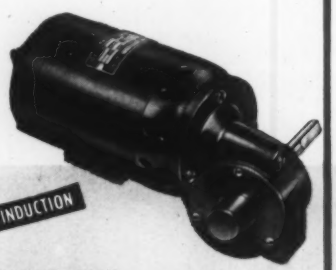
MAXIMUM TORQUE oz. in. *1.6 to 3.5.

BEARINGS: *Ball or sleeve.

*Dependent on type of motor used; i.e. Non-Synchronous Capacitor Motors, Torque Motors, Standard Synchronous Motors, Hysteresis Synchronous Motors.

GEAR HEAD: Ratios from 6:1 to 3600:1. Torques up to 300 in. oz. at low speeds. Range of output speeds from ½ r.p.m. to 600 r.p.m.

Spur gears are used throughout. The high speed pinion, cut on the rotor shaft, assures extreme accuracy, and maximum strength is achieved by supporting the output shaft in large, solid bronze bearings.



MODEL 2900 with GEAR UNIT

TYPE: 2 Pole, 4 Pole Induction.

DIAMETER: 3-5/16".

LENGTH: 7-5/64" to 8-11/64".

SPEED: 1650 to 3600 R.P.M. depending on type of motor used—Non-Synchronous, Standard Synchronous, Hysteresis Synchronous, or Torque.

H.P.: 1/70 to 1/15 depending on length of stacking.

TORQUE OUTPUT: Up to 60 in. lbs. depending on ratio.

BEARINGS: Permanently lubricated and sealed ball bearings.

RATIOS: 10:1 to 60:1.

MODEL 29-500 with GEAR UNIT

TYPE: Universal AC/DC or Shunt.

DIAMETER: 3-5/16".

LENGTH: 7-13/64" to 7-37/64".

SPEED: 5000 to 10,000 RPM.

H.P.: 1/70 to 1/4 depending on length of stacking.

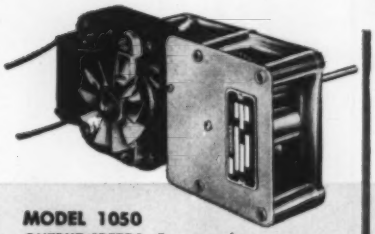
TORQUE OUTPUT: Up to 60 in. lbs. depending on ratio.

BEARINGS: Permanently lubricated and sealed ball bearings.

RATIOS: 10:1 to 60:1.

line of Fractional H.P. Gear Motors

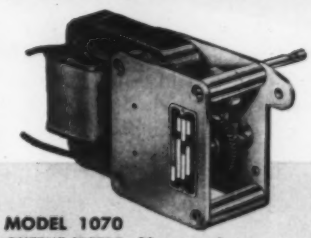
2 POLE, DOUBLE BEARING



MODEL 1050

OUTPUT SPEEDS—1 rpm and up.
GEARS—Molded nylon in high-speed for quiet operation, stamped, cut or sintered in low-speed section.
BEARINGS—Sintered porous bronze with large oil reservoirs for assured self lubrication.
MOUNTING—Front only; choice of ten holes tapped as required.
ROTATION—Unidirectional (CW or CCW).
SHAFT—3/16 in. dia. std. with length to meet requirements.

starting torque, in. lbs.	no load rpm	full load					stack A. in.
		torque, in. lbs.	rpm	input (115-V) amps.	input (115-V) watts	gear ratio	
20	6.8	33	6	.34	18	500:1	⅝
15	10.2	24	9	.34	18	333:1	⅝
7	17	19	15	.46	24	200:1	⅝
5	43	11	30	.46	24	100:1	⅝
2.25	75	4.5	68	.46	24	45.4:1	⅝
2.0	122	2.4	108	.75	35	27.8:1	⅝
1.5	159	1.9	140	.81	40	21.4:1	⅝



MODEL 1070

OUTPUT SPEEDS—30 rpm and up.
GEARS—Molded nylon in high-speed section for quiet operation; stamped, cut or sintered in low-speed section. Also available, when specified, with cut gears throughout.
BEARINGS—Sintered porous bronze with large oil reservoirs for assured self-lubrication.
MOUNTING—Front only; choice of three holes tapped #8-32 and/or two .161 in. dia. holes.
ROTATION—Unidirectional (CW or CCW) as specified.
SHAFT—3/16 in. dia. std. with length to meet requirements.

starting torque, in. lbs.	no load rpm	full load					stack A. in.
		torque, in. lbs.	rpm	input (115-V) amps.	input (115-V) watts	gear ratio	
2.25	82	4.5	74	.46	24	37.8	⅝

MODEL 1150

OUTPUT SPEEDS—60 rpm—other gear trains for different output speeds available, state requirements.
GEARS—Molded nylon in high speed section for quiet operation. Stamped, cut or sintered for low-speed section.
BEARINGS—Sintered porous bronze with large oil reservoir for assured self-lubrication.
MOUNTING—Front only, choice of ten holes tapped as required.
ROTATION—Unidirectional (CW or CCW as specified).
SHAFT—1/4 in. dia. std. with length to meet requirements.

starting torque, in. lbs.	no load rpm	full load*					stack A. in.
		torque, in. lbs.	rpm	input (115-V) amps.	input (115-V) watts	gear ratio	
16	75	24.5	60	3.1	124	50:1	1¼

*Intermittent duty (10 seconds On, 50 second OFF continuously).

REDUCTION UNITS

Designed for direct mounting on Howard motors, the speed reducers illustrated in this section give a wide range of speeds and torque in both open and closed types; single or two stage. Closed units are grease packed for efficient lubrication with minimum maintenance. For heavy duty, high torque applications, Models A-7 and A-12 are especially recommended. *Twelve Howard universal motors (not shown) are available as gear motors with the gear units illustrated.*

Hundreds of standard ratios permit accurate selection of output speed. Most of the gear units can be supplied with double shaft extensions where required. Our gear reducers are intended for use only with Howard motors.

Ratings are maximum under ideal operating conditions. Each application requires careful consideration based on having description of Load & Duty Cycle.

MODEL A-1
Single Reduction, Open
Maximum Ratio: 58:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%

MODEL A-3
Double Reduction, Open, With Mounting Pad
Maximum Ratio: 2700:1
Minimum Ratio: 40:1
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 30%

MODEL A-4
Single Reduction, Closed
Maximum Ratio: 58:1
Minimum Ratio: 3:
TORQUE
Continuous Duty: 5 in. lbs.
Intermittent Duty: 10 in. lbs.
Efficiency: Max. 45%

MODEL A-5
Double Reduction, Closed
Maximum Ratio: 2700:1
Minimum Ratio 40:1
TORQUE
Continuous Duty: 10 in. lbs.
Intermittent Duty: 20 in. lbs.
Efficiency: Max. 30%

MODEL A-6
Single Reduction, Closed
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 12 in. lbs.
Intermittent: 25 in. lbs.
Efficiency: Max. 65%

MODEL A-7
Double Reduction Closed, Heavy Duty
Maximum Ratio: 2600:1
Minimum Ratio: 21.5:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 50%

MODEL A-12
Combined Worm and Spur Gears
Maximum Ratio: 525:1
Minimum Ratio: 6.7:1
TORQUE
Continuous Duty: 100 in. lbs.
Intermittent Duty:: 250 in. lbs.
Efficiency: Max. 50%

MODEL A-26
Single Reduction, Closed
Heavy Duty
Maximum Ratio: 60:1
Minimum Ratio: 3:1
TORQUE
Continuous Duty: 50 in. lbs.
Intermittent Duty: 100 in. lbs.
Efficiency: Max. 80%

POWERED BY HOWARD

HOWARD INDUSTRIES, INC., 1735 State St., Racine, Wis., Telephone ME 2-2731, Teletype: RAC344

Sales Offices:
Camden, New Jersey, 300 Broadway, WO 4-9733
Chicago 4, Ill., 208 S. LaSalle St., CE 6-5126
Cincinnati 2, O., 1077 Celestial St., PA 1-2985
Festus, Mo., 1049 Front Street, YE 7-3606
Los Angeles 36, 942 S. La Brea Ave., WE 8-2444
New York 1, Empire State Bldg., LO 4-7992
Tyler, Texas, 2512 Sheryl Lane, TY 4-5355

Representatives in Principal Cities—Consult Your Classified Phone Book

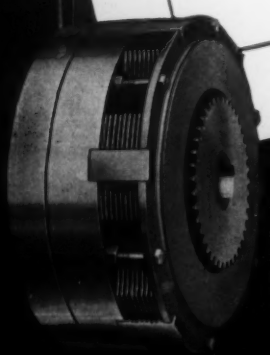
Buy Defense Bonds

DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS · LS LOYD SCRUGGS COMPANY

an invitation to design engineers . . .

You are Cordially Invited
to Utilize the
Many Outstanding Advantages
FAWICK MAGNETIC CLUTCHES
can Provide for Machines
Requiring
Precise Automated
POWER TRANSMISSION CONTROL
and to use
Fawick Engineering Experience
in this Field
for the Best Solution
to Your Specific Problem

Circle 471 on Page 19



Magnetics are the clutches of the future — **and FAWICK MAGNETICS head the list for performance and dependability.** They provide fast, dependable response — with excellent torque-vs.-size ratio, consistent high performance, and instant response to limit switches, relays, punched tape, or other electric or electronic control.

Sizes range from 2¼" to 13¼" in diameter, torque ratings from 27 inch-pounds to 66,000 inch-pounds. For detailed information write for bulletin M-102 or call the Home Office, Cleveland, Ohio.

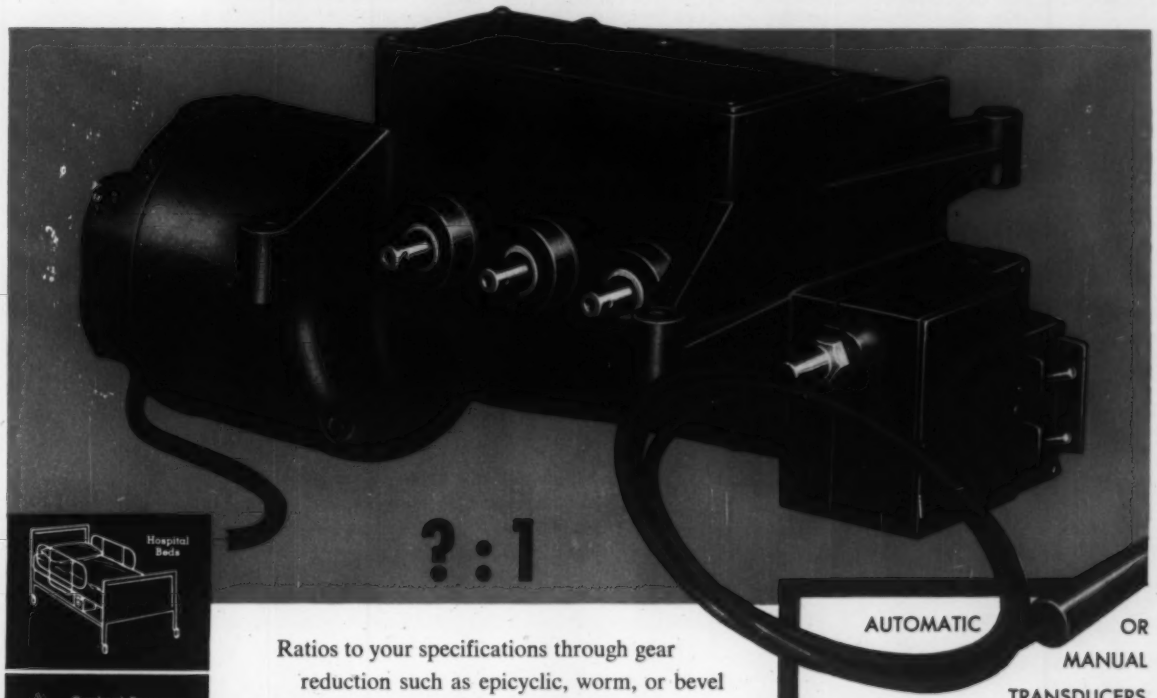
FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

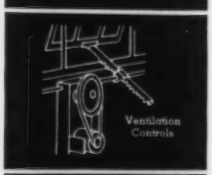
FAWICK
MAGNETIC

FAWICK MAGNETICS—WORLD'S FINEST ELECTRIC CLUTCHES

Franklin INST-O-VERSE® Motors

ENCOURAGE FRESH THINKING FOR NEW PRODUCT APPLICATIONS WHERE GEAR REDUCTION IS NEEDED





Ratios to your specifications through gear reduction such as epicyclic, worm, or bevel and other gears, PLUS instant, full-power reversibility extends power-package applications. These open new possibilities for competitively priced, high-reliability products. Hospital beds and garage doors are but two of today's newer products improved with these Franklin Motors.

AUTOMATIC OR MANUAL TRANSDUCERS ENERGIZE SINGLE OR DOUBLE POLE SWITCHES FOR ON, OFF, FORWARD OR REVERSE OPERATION OF ONE OR MORE OUTPUT SHAFTS.

Franklineer YOUR PRODUCT FOR DEPENDABILITY

Invite us to confer on your projects involving application-engineered fractional motors. INST-O-VERSE® gear motors represent only one of many "firsts" we offer for the products you can "Franklineer" for today's and tomorrow's better business. WRITE FOR Franklin INST-O-VERSE® folder and catalog . . .

INSTANT-REVERSING MOTORS

⅙ TO 1 H. P.

Franklin Electric Co., Inc.
HOME OF DEPENDABLE ELECTRIC MOTORS
BLUFFTON, INDIANA

Circle 472 on Page 19

Another Formica "first"

new ... FORMICA® fabricated parts

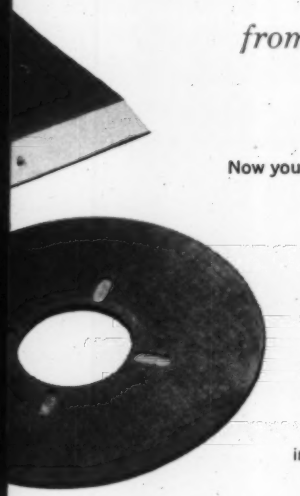
Laminated Plastic

vital fabricated parts

for missiles, spacecraft and aircraft, automotive, machinery, electrical machinery, instruments and other manufacturing industries. Produced and delivered faster by your regional Fabricator of Industrial Formica laminated plastics strategically located near you.

service now available locally...

from your Fabricator of Industrial Formica laminated plastics



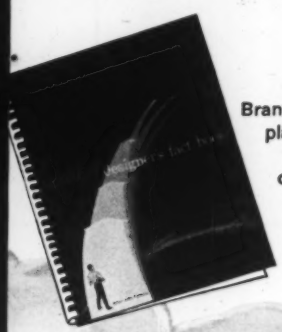
Now you get fabricated parts faster, direct from your own local Fabricator of Industrial Formica laminated plastics.

This new nationwide network of regional fabricators represents over 50 times the productive capacity ever offered for this purpose. It saves days and weeks on delivery by giving you a thoroughly competent fabricator practically in your own backyard.

The new service recognizes the need of industry for a dependable, big volume source of fabricated parts. Formica is proud to be the first to make available field fabrication facilities with these four key advantages:

1. **Faster, direct service.** Truckload or tote-boxful, you'll get parts faster direct from your regional Fabricator of Industrial Formica laminated plastics.
2. **High quality production** of Formica laminated plastic parts by plastics fabricating specialists.
3. **Application engineering service** from Formica's home and district offices, as well as through field fabricators.
4. **Widest grade selection.** Streamliner inventories maintained of 42 standard grades; most can be shipped within 48 hours. Ample research facilities for new grade development.

For further information on how the new Formica field fabricator program will speed up your production schedules, get your free copy of "Man of Many Parts." Write Formica Corporation, subsidiary of American Cyanamid, 4514 Spring Grove Ave., Cincinnati 32, Ohio.



new fact book . . . free!

Brand new concept in the presentation of laminated plastic properties and application data. Valuable aid to designers, production engineers, purchasing agents. Send today for your free copy.

FIF

ALBUQUERQUE, N. M.
Plasticrafts, Inc.

ARLINGTON, VA.
Milton H. Brooks & Son

ATLANTA, GA.
Southeastern Plastics Sales Co.

BRISTOL, VA.
Williams Co.

BUFFALO, N. Y.
Curbell, Inc.

CHICAGO, ILL.
Colonial Kolonite Co.
Tingstol Co.

CINCINNATI, OHIO
Aqua Sportsman Inc.
Durham Mfg. Co.

CLEVELAND, OHIO
Jaco Products Co.

COLORADO SPRINGS, COLO.
Empire Plastics

COLUMBUS, OHIO
Dayton Plastics, Inc.

DAYTON, OHIO
Dayton Plastics, Inc.

DENVER, COLO.
Plasticrafts, Inc.

EAST RUTHERFORD, N. J.
Insulating Fabricators, Inc.

EL CAJON, CALIF.
Dutton Mfg. Co.

FORT WORTH, TEXAS
Plastelite Engineering Co.
Service Engineers, Inc.
Standard Parts & Equip. Corp.

GIBSONVILLE, N. C.
Engineered Plastics, Inc.

GRAND RAPIDS, MICH.
Novel Products

HOUSTON, TEXAS
Houston Gasket & Packing
F. H. Maloney Co.
Replacement Parts Co.

HUNTINGTON, W. VA.
O'Neill Industrial Plastics, Inc.

INDIANAPOLIS, IND.
Automatic Machinery Co., Inc.

JACKSONVILLE, FLA.
St. John's Fdry. & Mch. Co., Inc.

KANSAS CITY, MO.
Brooks Beatty Co.

LOS ANGELES, CALIF.
Conroy & Knowlton, Inc.
Leed Insulator Corp.
Tri-State Supply Co.

LOUISVILLE, KY.
C. Lee Cook Co.

MEMPHIS, TENN.
Norrell, Inc.

MIAMI, FLA.
Commercial Plastic & Sup. Corp. of Fla.

MILWAUKEE, WISC.
General Plastics, Inc.

NASHVILLE, TENN.
Plastic Fabricator Co.

NEW ORLEANS, LA.
Prager, Inc.

NEW YORK, N. Y.
Commercial Plastics & Sup. Co.
Frank Products
Thomas J. Long, Inc.

OZONE PARK, N. Y.
Comco Plastics

PHILADELPHIA, PA.
Laminated Materials

PITTSBURGH, PA.
Earl B. Beach Co.

POMONA, CALIF.
Plastic Stamping, Inc.

ROCHESTER, N. Y.
General Circuits, Inc.

ST. LOUIS, MO.
Harris Mfg. Co.

ST. PAUL, MINN.
Plastics, Inc.

SAN DIEGO, CALIF.
Ridout & Co.

SAN FRANCISCO, CALIF.
Laminated Fabricators
Tri-State Supply Corp.

SEATTLE, WASH.
Tri-State Supply Corp.

TAMPA, FLA.
Manatee Corp.

UNIONVILLE, CONN.
Fabricon Corp.

WATERTOWN, MASS.
Insulating Fabricators of N. E.

WEST ALLIS, WISC.
Colonial Kolonite Co.

FORMICA®
Laminated Plastic

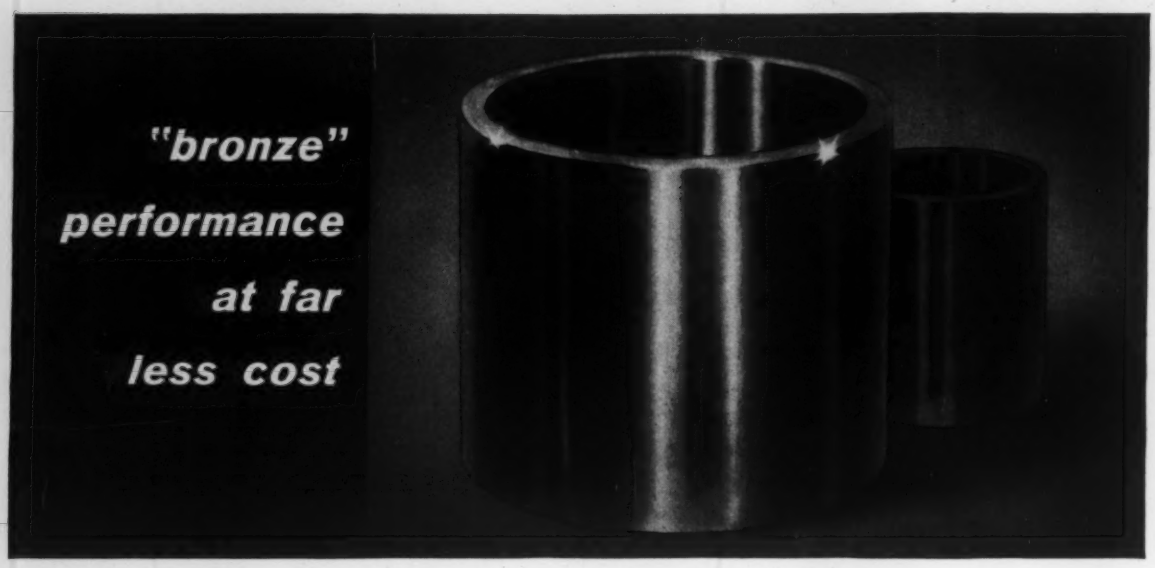
A product of CYANAMID

Laminated plastic sheets, tubes, rods, molded parts. Field fabricator service.

FI-2006

Circle 473 on Page 19

introducing NEW IRON OILITE 212 BEARINGS



The important difference between the porous bronze bearing (right) and the all-new Iron OILITE* 212 Bearing (left) is cost. While both bearings give long, maintenance-free service, Iron Oilite 212 bearings now open the door to major savings for many equipment manufacturers.

Performance-proved in life tests and on actual products, Iron Oilite 212 bearings have a service life equal to porous bronze when used for products where corrosion is not a problem and mechanical strength requirements are within tolerable limits.

A high oil content — approximately 20% by volume — assures adequate lubrication for the lifetime of many end products. In addition, a unique built-in service factor gives Iron Oilite 212 bearings extraordinary protection against temporary overloads. They perform best when carrying medium to heavy loads at relatively low speeds and readily equal the performance of bronze at the high speeds required by home appliances, fractional horsepower motors, power tools, light machinery and other products.

It's another Amplex first . . . a typical example of how Amplex serves a growing number of original equipment manufacturers with "better quality at lowest cost". Use Amplex's extensive research and engineering facilities to your own advantage. Savings can be impressive if you require bearings in volume.

free sample

of **IRON OILITE 212** Bearing 1" ID x 1¼" OD x 1" Length and full information on request. Consult the Oilite engineer in your area. Find him in the Yellow Pages under "bearings" or write direct to Amplex. Address Dept. S-2.

COMPARISON OF TYPICAL PHYSICAL PROPERTIES

	Iron Oilite 212	Oilite Bronze
Porosity, % oil by volume	18 - 23	18 - 23
Ultimate Tensile Strength, (psi)	10,000	18,000
Compressive Yield Point, (psi)	9,500	20,000
Rockwell Hardness	RH - 35	RE - 65
Specific Gravity	6.1 - 6.5	6.4 - 6.7

* REGISTERED TRADEMARK
ONLY CHRYSLER MAKES OILITE

SINCE 1929 — A CHRYSLER OILITE PRODUCT

the most trusted name in powder metallurgy!

AMPLEX DIVISION
CHRYSLER CORPORATION, DETROIT 31, MICHIGAN
SELF-LUBRICATING BEARINGS • PRECISION PARTS • METAL FILTERS • FRICTION UNITS

KOHLER ENGINES

4-cycle Short-stroke Air-cooled

MODEL

K160

- Balanced crankshaft— ball bearings at both ends.
- Externally mounted breaker points.
- Positive splash lubrication.
- Cylinder and crankcase are made of metallurgically controlled close grained cylinder iron.
- Mechanical governor for accurate R.P.M. control

Industrial Sweeper

Kohler engines are conservatively rated, quick-starting, reliable.

Experienced application engineers are ready to help you choose the engine that will do the job.

Kohler Co. has manufactured internal combustion engines for 38 years.

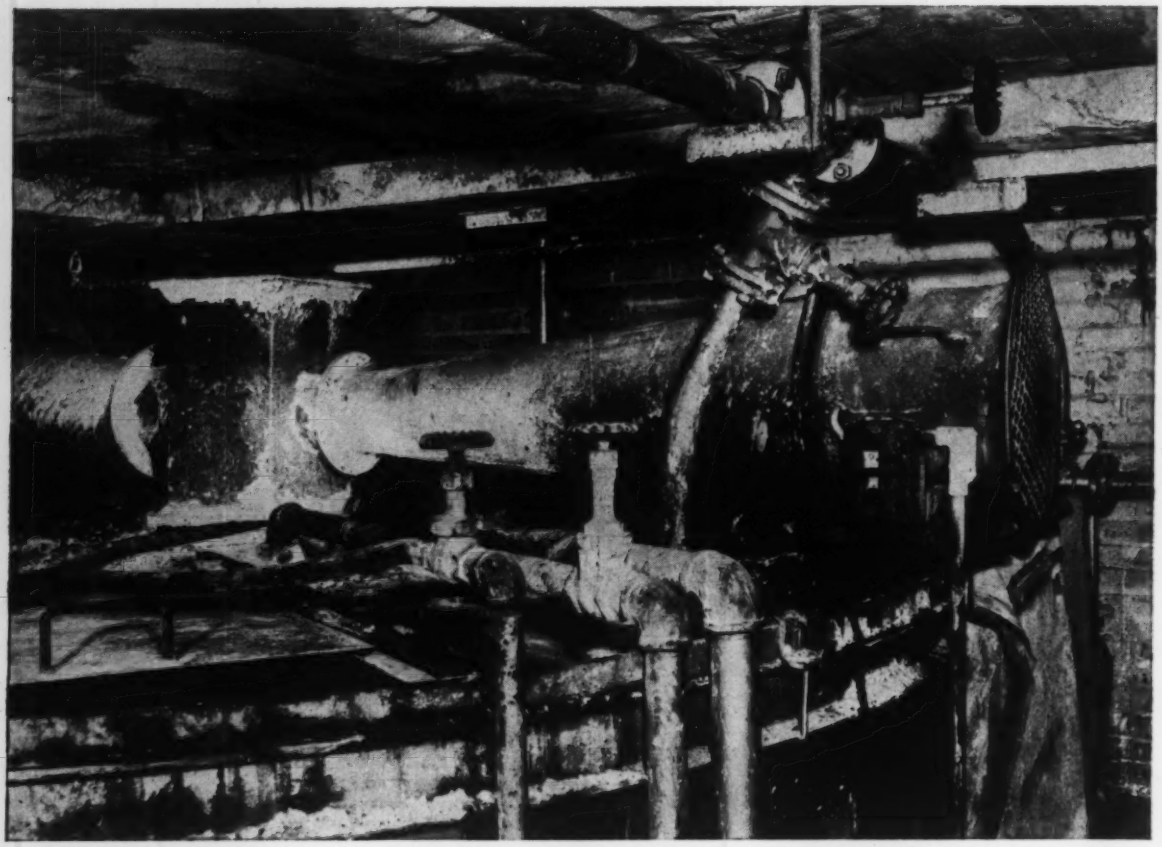
Send for illustrated booklet.

FROM 3 TO 24 H.P.

KOHLER CO. Established 1873 KOHLER, WIS. U.S.A.

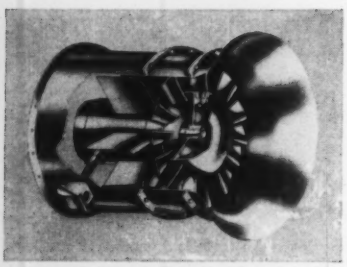
KOHLER OF KOHLER

Enameled Iron and Vitreous China Plumbing Fixtures • Brass Fittings • Electric Plants • Air-cooled Engines • Precision Controls



Efficient Joy Axivane Fans vent corrosive fumes from tanks in chemical plant producing fatty acids and polyesters.

CORROSIVE ATMOSPHERE NO PROBLEM FOR THIS JOY AXIVANE® FAN



Other Bulletins also available:
Compressor 268C-64B
Dust Collectors 267D-64B

Joy Axivane Fans are used to vent extremely corrosive fumes in a number of electroplating and chemical plants across the land. Efficient, quiet, compact and durable Joy Axivane Fans are available in alloy steels or with special coatings to resist the most corrosive atmospheres.

Hundreds of standard models are available with either V-belt or integral drive. They are supplemented by a design service which will give you Joy Axivane Fans with whatever efficiency, capacity or pressure your installation requires.

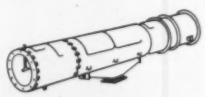
For details write for Joy Fan Bulletin 268F-64B.

Joy Manufacturing Company, Oliver Building, Pittsburgh 22, Pa.
In Canada: Joy Manufacturing Company (Canada) Limited; Galt, Ontario.

WSW 17365-268

JOY ... EQUIPMENT FOR INDUSTRIAL PLANTS ... FOR ALL INDUSTRY

INDUSTRIAL COMPRESSORS

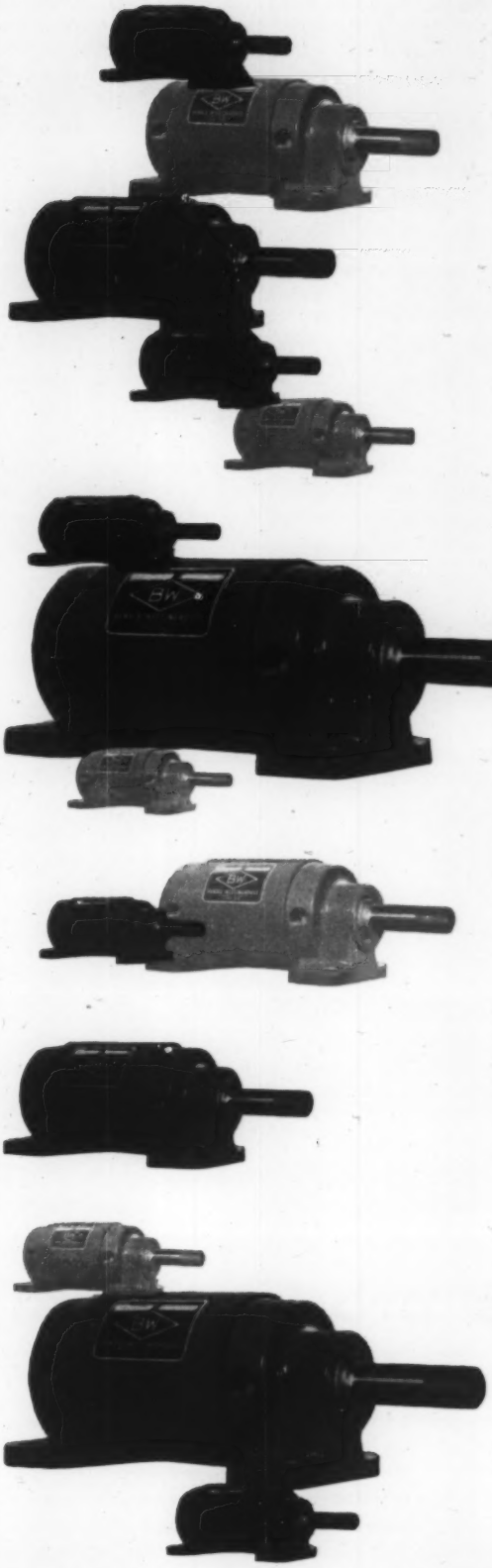


DUST COLLECTORS

ELECTRICAL CONNECTORS

FANS AND BLOWERS

Circle 476 on Page 19



Whatever your power cylinder needs . . .

BENDIX-WESTINGHOUSE NOW OFFERS THE MOST EFFICIENT ANSWER

Expanded line features new piston models, both air and hydraulic; as well as diaphragm types

The quality-built piston type air and hydraulic cylinders added to the Bendix-Westinghouse line now offer you the same precision, dependability and long life for which our diaphragm type air cylinders have always been noted.

Piston model features that assure high-quality performance with maximum economy include: perfect alignment . . . high-tensile, heavily chromed rod . . . metal rod scraper . . . self-adjusting packings . . . key-type locking ring . . . 360° rotation of parts . . . variety of mountings . . . full cushioning without length increase . . . heavy wall precision-honed tubing . . . cartridge-type rod bearing, built to J.I.C. standards . . . standard diameters up to 8″.

Standard Bendix-Westinghouse power cylinder models are available for immediate delivery. We also custom-build power cylinders to your specifications.

Our experience with all kinds of specialized power cylinder problems is at your service.

Write for literature today

Bendix-Westinghouse

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

BW

Manufacturer cuts product cost

Problem: A Spokane, Washington manufacturer sold band-mill saws to the lumber industry. Soaring expenses were pushing unit costs out of sight. To remain competitive, he had to sell his product for less. He called in his local Century Electric sales engineer for help.

Solution: The Century Electric sales engineer studied the motor drive for the unit. He proposed a new gearmotor drive to replace the cumbersome mechanical transmission system. The compact Century Electric gearmotor required less space and was easier to install and maintain. Fewer parts were required—assembly was simplified. Savings in manufacturing costs: $192. The manufacturer was well on his way to solving his cost problem.

$192 with Century Electric motor

More than a motor: This is another example of why you get more than a motor when you take your motor problems to Century Electric. You will have the help of experts who think, sell and apply motors—and nothing *but* motors—day after day. They may be able to show you how to get better performance and cut costs for your product.

For more information, contact your nearest Century Electric Sales Office or Authorized Distributor.

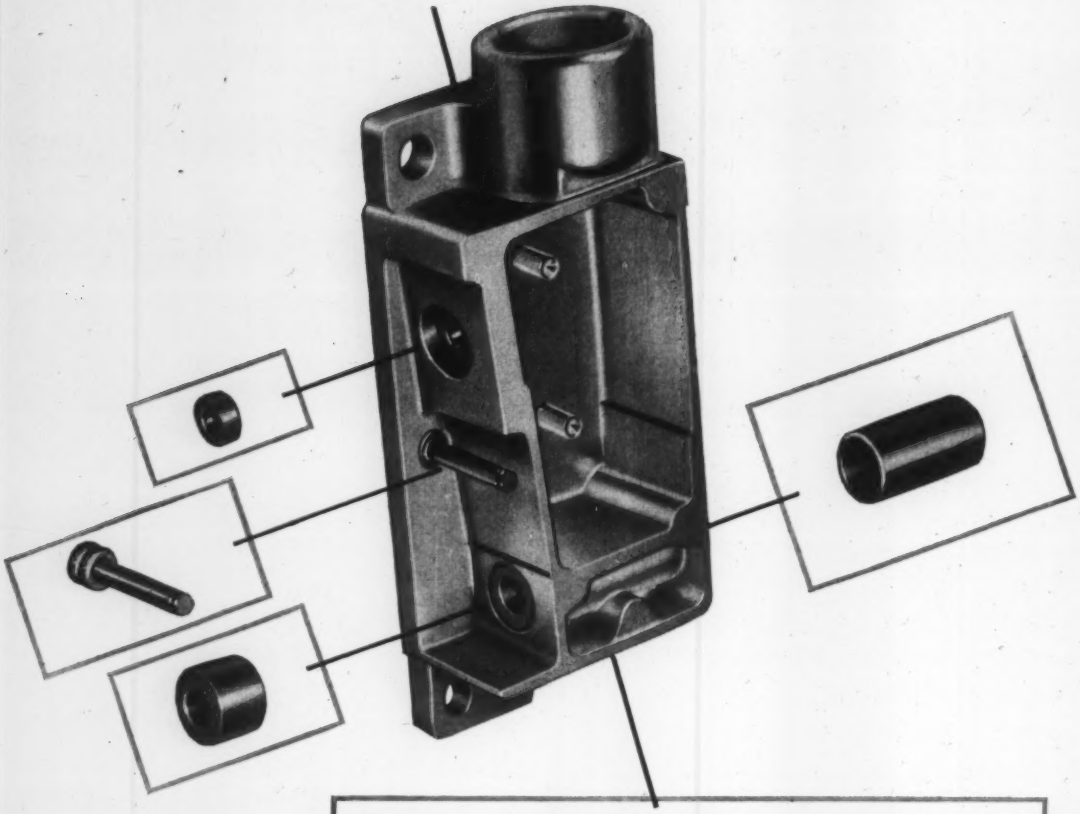
CENTURY ELECTRIC COMPANY

St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century

58-2

Circle 478 on Page 19



"Hot-Shot Assembling"

with MADISON-KIPP zinc and aluminum die castings

"Hot-shot assembling" is a shop term but it is literal, because inserts are put in place and liquid metal under high pressure is shot into the die to surround and anchor the inserts in the die casting.

In many cases the advantages of cast-in inserts provide substantial cost savings even though the casting process is slower than when no inserts are involved.

The seasoned and skilled Madison-Kipp mechanics have had long experience in "hot-shot assembling." They may be able to assist you in your problems.

Please clip this ad as a reminder to contact us when you have die casting requirements.

kipp

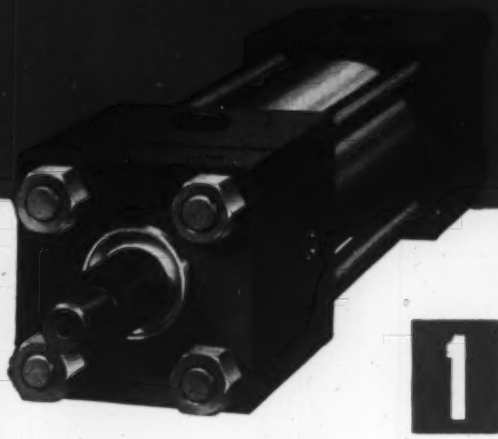
MADISON-KIPP CORPORATION
210 WAUBESA STREET • MADISON 10, WIS., U.S.A.

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

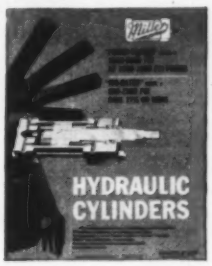
Circle 479 on Page 19

Specify Miller HYDRAULIC CYLINDERS

FOR UNLIMITED SEAL LIFE!



Request Bulletin JH-104N for complete data plus helpful charts on column strength, cylinder forces, factors of safety, acceleration, pipe pressure losses, etc.



1 ALL TEFLON* SEALED Against External Leakage

TEFLON is impervious to all known hydraulic fluids, including all fire-resistant and special types—and withstands temperatures from —100°F. to plus 450°F.

TEFLON SHEF SEAL AT TUBING ENDS

No blind assembly. Is

Shear-proof
Heat-proof
Extrusion-proof
Fluid-proof

TEFLON SEALS ON PISTON ROD AND BUSHING

Teflon rod flange seal requires no adjustment. Teflon bushing seal is shearproof. Teflon wiper keeps dirt out.

TEFLON SEALS ON BALL CHECK AND ADJUSTING SCREW

Non-protruding, self-locking, cushion adjusting screw interchangeable with ball check for easy access.

2 CASE-HARDENED CHROME PLATED PISTON RODS

Provide foolproof protection against seal failures resulting from rod damage. The Miller case-hardened rods (50-54 Rockwell C) give practically complete immunity to damage from hammer blows, wrench-dropping, mishandling, etc. The hard chrome plating over the case-hardened rods protects against scratch-damage and rust.

AVAILABLE IN TWO TOP QUALITY LINES

JOB-RATED
Model "J"

PRICE SAVINGS OF 27% OR MORE!

19 mounting styles, all strokes, cushioned and non-cushioned. Large selection for immediate shipment.

BORE	SEVERE OPERATING CONDITIONS	MODERATE OPERATING CONDITIONS	YOU SAVE THIS % IN PRICE OVER STANDARD 2000-3000 PSI CYLINDERS
1½"	1500 PSI	2500 PSI	27%
2	1500	2500	27%
2½	1000	1500	28%
3¼	1500	2500	32%
4	1000	1500	35%
5	800	1200	37%
6	800	1200	43%
8	500	800	50%
10	500	800	71%
12	500	800	76%
14	500	800	*Not Available in 2000-3000 PSI*

POWER-PACKED
Model "H"

50% More Power Per Cylinder Dollar!

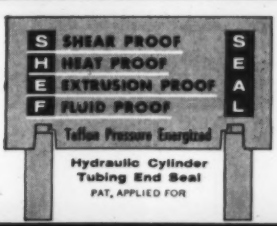
For

3,000-5,000 P.S.I.

1½" through 12" bores, 17 mounting styles, strokes up to 22 ft., cushioned and non-cushioned. Large selection for immediate delivery.

Circle 480 on Page 19

*DuPont trademark for its tetrafluoroethyline resin

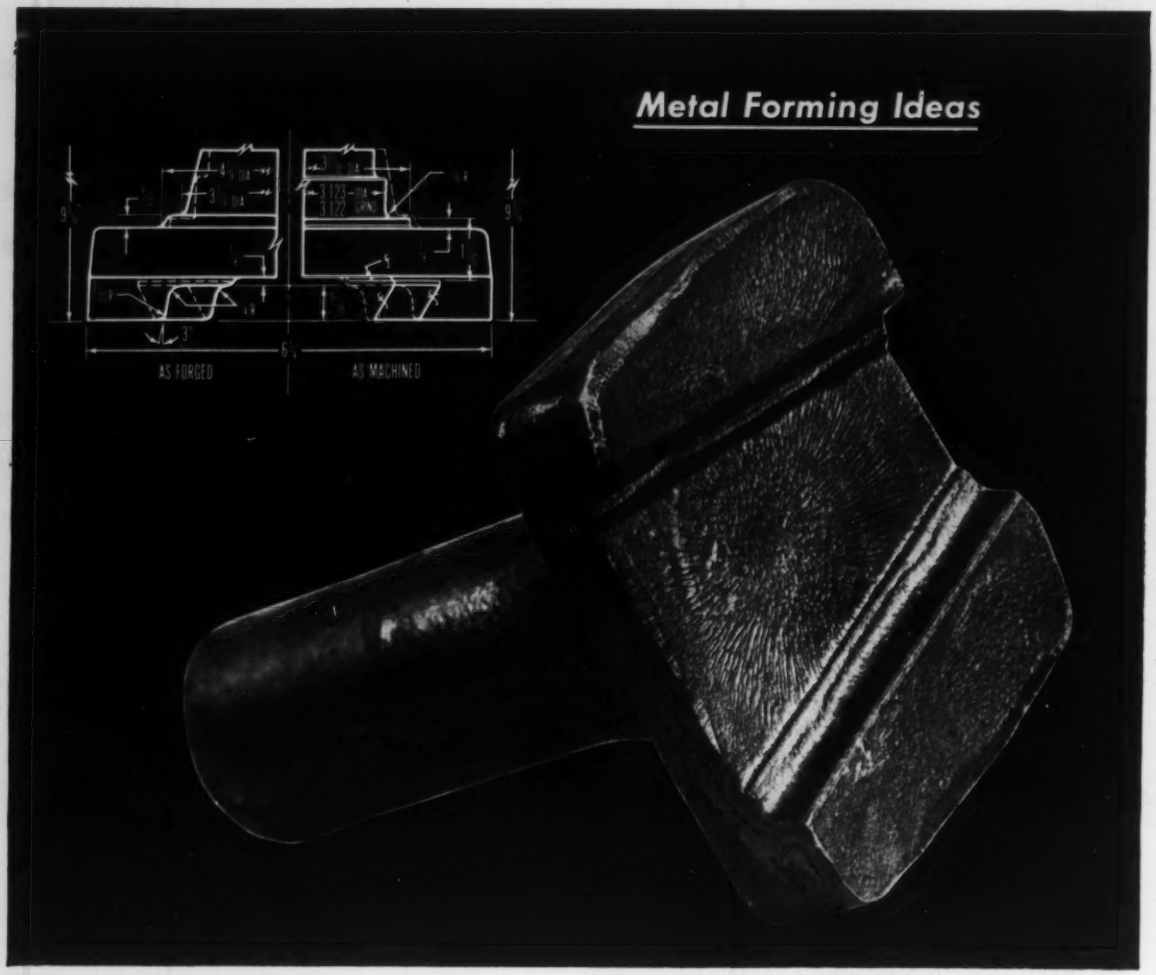


OTHER MILLER QUALITY FEATURES

- Solid Steel Heads, Caps and Mountings.
- Precision-Honed Barrels.
- Rust-Resistant Coating on All Non-Wearing Surfaces.
- Space-Saving "Square" Design.

MILLER FLUID POWER
DIVISION OF FLICK-REEDY CORPORATION

2006 N. Hawthorne Ave. Melrose Park, Ill.



How upsetting saves metal – reduces machining

Key part in a new multi-purpose farm tractor by Minneapolis-Moline was a steering link pedestal which involved unusual requirements both as to its final performance and actual production.

On the performance side, the design of forged pedestal gives Minneapolis-Moline customers a three-in-one tractor. In a matter of minutes change-over of three different front ends is made through the dovetailed groove.

From the production standpoint, the part was unusual in both shape and design—included a dovetailed groove in its head, plus an off-center shaft.

The requirement: A metal and a forming method which could produce this unusually shaped key component to meet all requisites on strength, lightweight, and yet afford maximum savings on both metal and machining of the forging.

The "Task-Forging" team at COMMERCIAL, working closely with Minneapolis-Moline engineers, proved that upset forging, despite the fact that it is rarely considered for the forming of off-center shaft components – particularly when they also involve a dovetail groove swaged in one end like this one —could best meet this requirement on every count. The steering link is now being successfully produced as an upset forging on an 6" upsetter by COMMERCIAL.

As an upset forging it is more than strong enough to do the job. The controlled grain flow and efficient metal distribution afforded by upset forging assures maximum tensile and torsional strength. Equally important, there are no hidden, inside faults in the finished part—sound, dense, non-porous, forged metal from center-to-surface eliminates rejects, makes machining more effective.

At a finished weight of 22½ lbs. (after machining) the steering link is easily light enough. And since the weight of the upset forging (before machining) was 27 lbs., the important savings in both metal and machining made possible by the inherent close tolerances of the upset forgings produced by COMMERCIAL are obvious.

Whether you're looking for help in the forming of a new component or only considering an improvement in the forming of an already existing part, "Task-Forging," COMMERCIAL's new metal forming service—backed by over 30 years of metal forming experience, plus specialized equipment which includes 1½" thru 8" upsetters – may be able to help you. Address inquiries to Commercial Shearing & Stamping Company, Dept. S-8, Youngstown 1, Ohio.

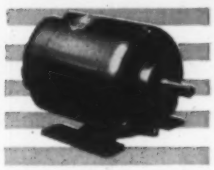
COMMERCIAL
shearing & stamping

Circle 481 on Page 19

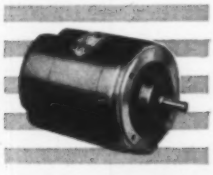
DESIGN FLEXIBILITY
plus PROVEN PERFORMANCE...

R&M UNIVERSAL MOTORS

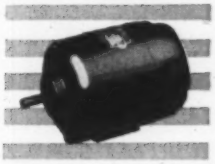
foot mounting



end mounting



pad mounting



When you build-in R&M Motors... you build in customer satisfaction

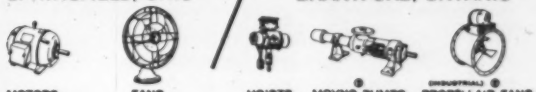
R&M Universal Motors have proven to be dependable performers in hundreds of OEM products used by millions of satisfied customers. You can be sure your product will give more years of reliable, trouble-free operation if it's powered by R&M.

Design engineers prefer R&M Universal Motors for their broad design flexibility. Consider these variables on standard models: AC or DC operation . . . 1/50 to 1/2 hp . . . pad, foot or end mounted . . . rotation in either direction . . . open or totally enclosed. Custom designs with special ratings are also available.

Build customer satisfaction into your next product! Write today for R&M Bulletin 444-MD!

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO | BRANTFORD, ONTARIO



Robbins & Myers build motors from 1/200 to 200 horsepower

Circle 482 on Page 19

Announcing

—AN ENTIRELY NEW LINE OF V-BELT DRIVES

NEW HIGH CAPACITY!
NEW SMALL SIZE!
MANY NEW SAVINGS!

Dyna-V is entirely new. In every detail, Dyna-V has been engineered to take advantage of today's great improvements in belt materials and metal alloys—resulting in V-belt drives that are sensationally compact.

Dyna-V is capable of handling up to three times as much horsepower in a given space. Dyna-V opens vast new possibilities for better, more economical machine design. And, in most instances *Dyna-V costs less!*

An entirely new high in strength and horsepower capability is packed into Dyna-V Belts. Cross section dimensions are substantially reduced—top width is much narrower. Dyna-V Sheaves are designed for these belts. Narrower grooves reduce face width—and weight. Costs are lowered. Smaller diameter sheaves and shorter center distances multiply savings.

Increased sheave strength for increased capacity is obtained through changes in design that utilize the full benefit of modern improvements in alloy metals. Dodge is noted for the superiority of its semisteel castings, to which now have been added ductile iron castings produced with the most modern electric furnace facilities.

Dyna-V Sheaves are equipped with Taper-Lock Bushings. The superiority of this mounting, patented by Dodge, is widely recognized. Taper-Lock's holding power is terriffic, yet it is "easy on, easy off." And Taper-Lock Bushings provide the additional advantage of interchangeability.

The benefits of Dyna-V go beyond compactness and initial low cost. Smaller sheaves reduce shaft overhang—increase bearing life. The dimensional stability of Dyna-V Belts (which are heat resistant, oil resistant, static conducting) solves the problem of belt matching. Every belt carries its full share of the load. The crowned top of Dyna-V Belts is a new concept in belt design. Combined with proved concave sidewall construction, it insures perfectly even load distribution between belt and sheave.

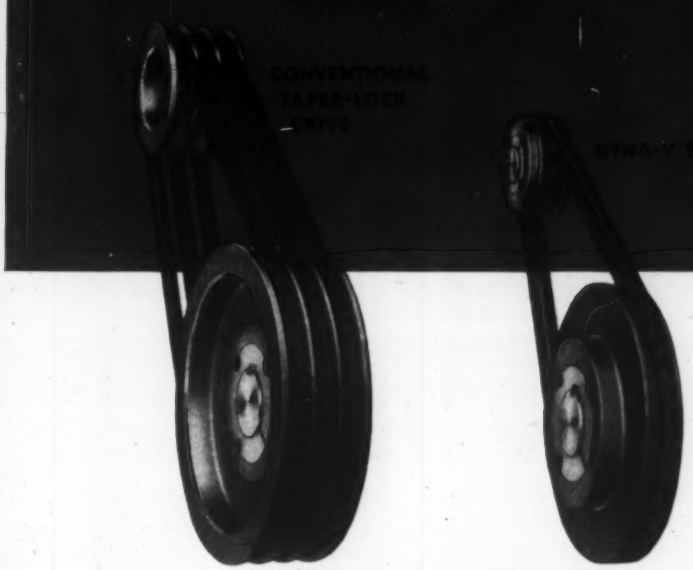
A complete bulletin on Dyna-V, including drive selection tables, will soon be ready. If you want one of the first copies, write us at once. Or see your local Dodge Distributor.

DODGE MANUFACTURING CORPORATION
3300 Union Street, Mishawaka, Indiana

DODGE

DODGE

Dyna V



Dyna-V Drives for capacities up to 50 horsepower are now available from stock, using the new belt cross section, "3V," and Dyna-V Taper-Lock Sheaves to match.

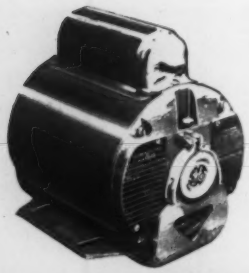
Dyna-V Drives for capacities up to 200 horsepower, using "5V" belts and sheaves will be available from stock in March. Larger sizes up to 1500 hp, with "8V" belts and sheaves, can be furnished on order.

COMPARISON, ILLUSTRATED ABOVE — 3 HP, 1750 RPM, 2.41 TO 1 RATIO

	BELTS		SHEAVES			CENTER DIS-TANCE	HP	WEIGHT (LBS.)	COST	
	Number	Size	O.D. Driver	O.D. Driven	Width				Per hp	Per Drive
CONVENTIONAL TAPER-LOCK DRIVE	3	A42S	4.15"	8.95"	2½"	12.3"	4.62	24.7	$5.91	$27.38
DYNA-V TAPER-LOCK DRIVE	2	3V400	3.35"	8.00"	1$\frac{3}{32}$"	10.8"	5.0	18.0	$4.50	$22.50
% SAVING *Savings vary with different sized drives*			19%	10%	56%	12%	+	27%	23.8%	17.8%

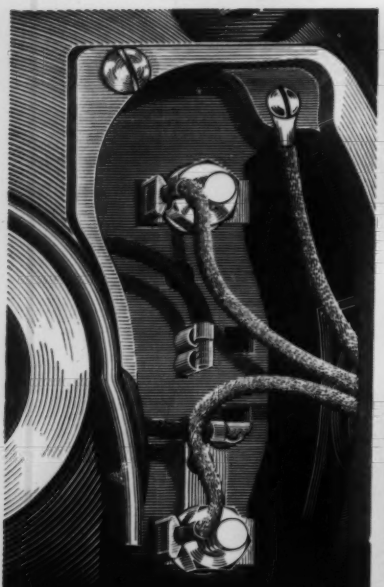
CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look in the *white* pages of your telephone directory for "Dodge Transmissioneer."

Circle 483 on Page 19



Here are 6 Reasons why

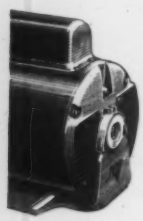
REDUCE



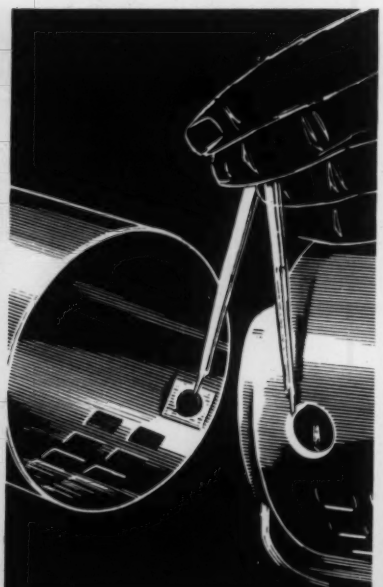
EASY TO HOOK UP

This enlarged wiring compartment saves hook-up time on the assembly line

Wiring compartments on G-E motors are now roomier and easier to work with. An enlarged opening allows greater accessibility. A narrower terminal board makes it easy to bring in leads from conduit. There are no extra studs on the board to result in "hook-up confusion." Easier, more accurate wiring results. How much can this extra value save you?



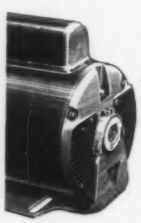
GENERAL ELECTRIC



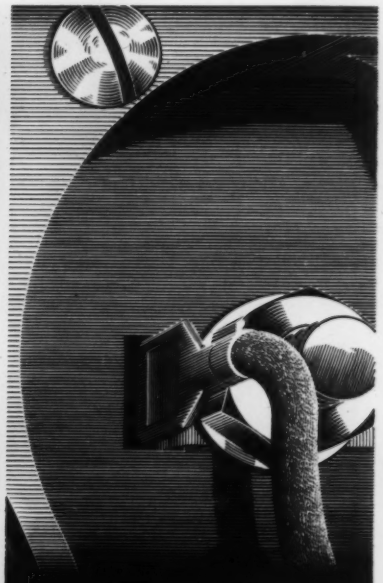
FAST CONDUIT CONNECTION

Special speed nut permits conduit connection from outside; cuts connection time 50%

Conduit connection is greatly simplified by single-thread speed nut welded inside the motor shell. This feature permits connection of conduit from outside the motor in half the time normally required with conventional lock nut. No waste of time fumbling with a loose nut, no possibility of dropping it in the motor or on the floor. It's a real time saver!



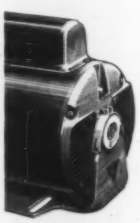
GENERAL ELECTRIC



FAST LEAD CONNECTION

Now plug-in connectors on all terminals cut wiring time in half

For the first time on all single-phase Form G motors, General Electric offers time-saving quick connectors on *all* external and internal contacts.* Wiring time is cut in half. (Studs have been retained for conventional wiring.) Simply plug in the leads. Fast, positive connections are assured. Try it yourself. You'll like this new General Electric extra value.



* Explosion-proof and a few special motors excepted.

GENERAL ELECTRIC

JUST ASK YOUR GENERAL ELECTRIC SALES ENGINEER

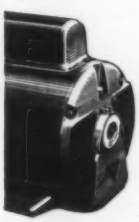
General Electric Form G motors . . .

ASSEMBLY TIME

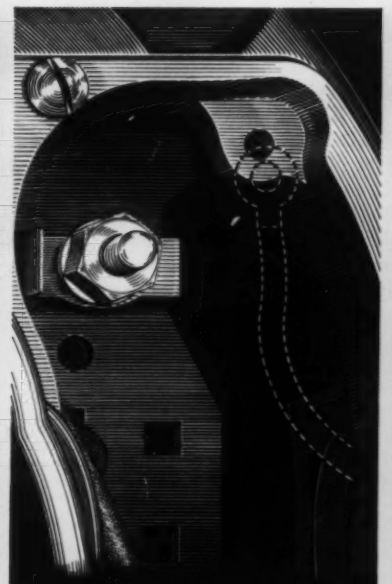
EASY-TO-READ NAMEPLATES

New permanent instructions and data simplify installation and servicing

Operating data on Form G motors is both legible and permanent to help you select, install and service without guesswork. The nameplate is engraved, then paint-filled for extra readability. Oiling instructions are lithographed on the terminal box cover plate. Lets your customers know exactly how *little* maintenance is required. *See* this extra value!



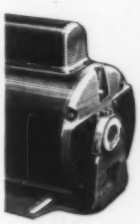
GENERAL ELECTRIC



SAFE, SIMPLE GROUND

Built-in grounding lug permits fast, easy grounding to meet UL standards

Now on Form G motors you get a built-in grounding lug that meets UL standards for grounded third lead when required. With a self-forming screw you can make ground connections quickly, easily and inexpensively. This feature assures safe, permanent grounds. There's no chance of disconnection during maintenance. Ask for details on this extra value.



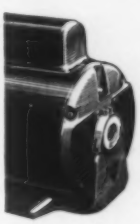
GENERAL ELECTRIC

COMPACT, LIGHTWEIGHT

Small, light Form Gs easy to assemble; cut handling and shipping costs

Up to 50 per cent lighter, 40 per cent smaller than old-style designs, General Electric Form Gs are easier to handle, faster to install. Compact motor requires less mounting space and material; cuts down "assembly-line fatigue" caused by heavier motors; reduces stock space and shipping costs. You can't help but *save* with compact, lightweight Form Gs!

702-90



GENERAL ELECTRIC

ABOUT THE NEW FORM G "EXTRA VALUE" FEATURES

Reduce power requirements and operating costs here...

JEFFREY

RIVETLESS CHAIN

for general conveying systems, overhead trolleys, scrapers

CHAIN STRENGTH is achieved from heat-treating quality steel; addition of bulk weight only increases power requirements. Jeffrey drop forged, heat-treated Rivetless Chain ranges to a maximum ultimate strength of 130,000 lbs. The weight —9 lbs. per foot.

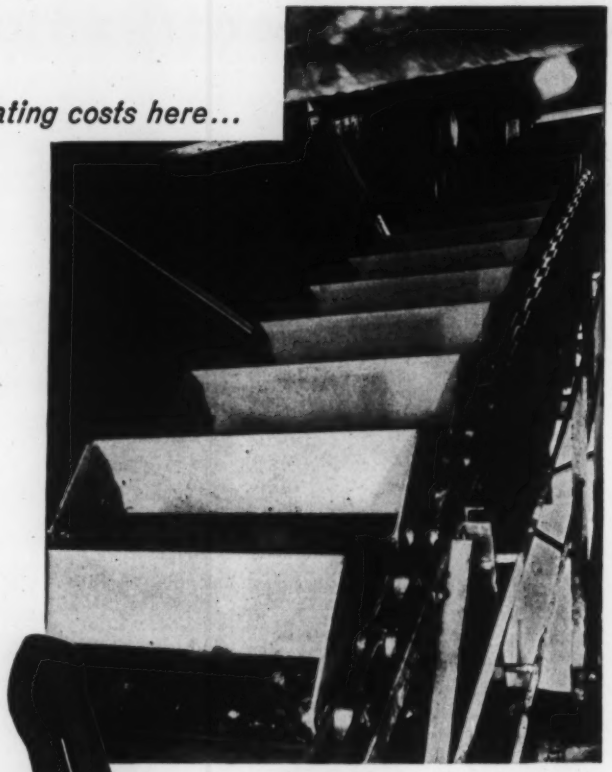
Within very broad limits, Jeffrey Rivetless Chain will operate over irregular courses in either vertical or horizontal directions.

Links and pins can be reversed when excessive wear is evident, thereby increasing chain life while greatly decreasing maintenance costs. Simplicity of design makes single link or section replacements fast and easy.

Jeffrey Rivetless Chain is detachable. Assembly is aided by the cutout portion of center link which allows the side bars to be brought together for ease of insertion or removal of the pin.

Whether replacing links or specifying a complete conveyor system, the Jeffrey district office or distributor in your area can make the job initially less expensive—ultimately more profitable.

Write for Catalog #899. The Jeffrey Manufacturing Company, 798 North Fourth Street, Columbus 16, Ohio.



Jeffrey Scraper Conveyor with two strands of rivetless chain

STRONG...
without needless bulk weight

DETACHABLE...
for fast, easy assembly—lower maintenance costs

ADAPTABLE...
to irregular courses, vertical or horizontal conveyors

Available in alloy heat-treated steel

JEFFREY

CONVEYING • PROCESSING • MINING EQUIPMENT...TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

to protect a product in process, storage or transit

THERE'S A CAPLUG* THAT WILL DO THE TRICK

take your pick from over 500 sizes
in a dozen different styles now in stock

* Molded of tough, flexible Polyethylene, Caplugs won't chip, break, shred or collapse. Easy to apply and a cinch to remove, they're most kind to threads and polished surfaces.

get a kit full of samples
in exchange for the coupon attached

Circle 486 on Page 19

CAPLUGS DIVISION,
PROTECTIVE CLOSURES CO., INC.
2201 Elmwood Ave., Buffalo 23, N.Y.

Mail a free assortment of Caplugs, literature and prices to us, without obligation.

NAME _____ TITLE _____

FIRM _____

ADDRESS _____

CITY _____ ZONE _____ STATE _____

TUTHILL automatic reversing pumps

- **Positive reversing action**
- **Require no valves**
- **Port positions remain constant**

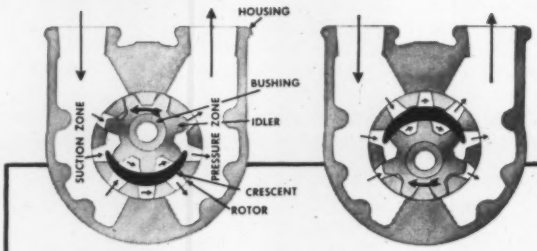
The model RCK above is typical of Tuthill's complete line of automatic reversing pumps . . . which use the time tested operating principle at the right to provide instantaneous, positive reversing action without the use of valves. The port positions remain constant regardless of the direction of shaft rotation. And all pumps provide uniformly high efficiency in both flow directions.

The automatic reversing design was developed by Tuthill for applications where the pump must be driven from a reversing shaft, or where machinery must be shipped without knowing the ultimate direction of the driving unit. These pumps have been enthusiastically accepted by designers and have proven their dependability in thousands of demanding applications such as large air compressors and machine tools.

375 Models

A complete selection of 375 models is provided with capacities from ⅓ to 200 gpm; for pressures to 400 psi; and speeds to 1800 rpm. Included are a complete assortment of stripped models specially developed for incorporation into manufactured products.

A 12-page catalog, No. 105, gives complete information on all Tuthill automatic reversing pumps. Write today for your copy. Or, if you desire, send drawings so that Tuthill's engineers can show you how the Model R reversing pump can be built directly into your product.



THE PUMPING PRINCIPLE

Tuthill automatic reversing pumps are based on the use of a rotor, idler gear and a crescent shaped partition which is integral with a moving part called the Idler Carrier.

Figure 1 shows how power is applied in counter-clockwise rotation to the rotor and transmitted to the idler gear with which it meshes. The space between the outside diameter of the idler and the inside diameter of the rotor is sealed by the crescent. When the pump is started there is an increase in volume as the teeth come out of mesh. This creates a partial vacuum, drawing the liquid into the pump through the suction port. The liquid fills the spaces between the teeth of the idler and rotor and is carried past the crescent partition to the pressure side of the pump. When the teeth mesh on the pressure side, the liquid is forced from the spaces and out through the discharge port.

When the shaft rotation changes from counter-clockwise to clockwise, the idler carrier (including the idler gear and crescent) automatically rotates 180° through the suction zone to the position shown in Figure 2 which *changes the direction of flow within the pump* without changing port positions. The idler carrier rotates in a cover casting fitted with stops so that the crescent can rotate only 180°—always through the suction zone. Upon resumption of counter-clockwise rotation, the crescent will swing back to the original position in Figure 1.

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities From ⅓ to 200 GPM; for Pressures to 1500 PSI; speeds to 3600 RPM.

TUTHILL PUMP COMPANY

953 East 95th Street, Chicago 19, Illinois

NFPA NATIONAL FLUID POWER ASSOCIATION

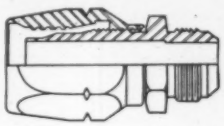
Circle 487 on Page 19

another NEW BOOK with that Eastman LOOK

36 pages on medium to low pressure hydraulic hose and tube assemblies

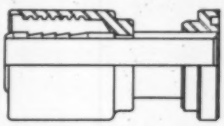
REUSABLE COUPLINGS FOR RUBBER COVER HOSE

Exclusive Eastman design directs flow of hose into machined recesses of insert and coupling body. Doubles the hold, assuring longer service. Pages 26 & 27.



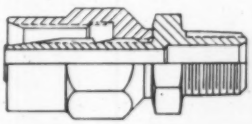
PERMANENTLY ATTACHED FLANGE HEAD COUPLINGS

Attractive, low cost permanent hose attachment—plus convenience of split-flange head couplings with 0 to 90° stems permitting full 360° positioning. Pages 20 & 21.



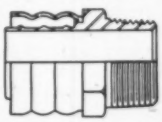
REUSABLE COUPLINGS FOR COTTON COVER HOSE

Eastman engineered two-piece coupling can be assembled without stripping hose. (Can also be used on thin rubber cover hose without removing cover.) Full details on pages 24 & 25.



PERMANENTLY ATTACHED COUPLINGS FOR SUCTION HOSE

For use on spiral wire return lines. Maximum orifice permits rapid return of hydraulic fluid assuring adequate supply from lever to load for top payload power. See page 31.



Eastman *first in the field*

SAFEGUARDING AMERICA'S LIFELINES OF MOBILE POWER

ARRANGED FOR YOUR CONVENIENCE TO MAKE IT EASIER FOR YOU TO:

Locate your required assemblies
Determine the proper couplings
Specify according to pressure

EASTMAN'S New Technical Bulletins on Hydraulic Hose and Tube Assemblies are the talk of the trade!

Here's the second in the series which you will want to send for right away—Technical Bulletin No. 100 on Medium to Low Pressure Assemblies. Working Pressures range from 3000 psi to 75 psi (for return suction lines).

Easy-to-use tables arranged opposite dimensional drawings for the entire Eastman line of Couplings: Permanently Attached, Clamp Type, Flange Type and Reusable—for One Wire Braid Rubber Cover, Cotton Cover and Suction Hose—plus necessary adapters and tube fittings.

This is a necessary companion to the first in Eastman's New Series of Bulletins—No. 200, on High Pressure Assemblies. Be sure that your personnel is supplied with copies of *each* of these modern bulletins.

Write today! Send the quick service coupon below.

EASTMAN MFG. CO., DEPT. MD-2, MANITOWOC, WISCONSIN

Please send me.....copies of Bulletin 100 on Medium to Low Pressure Eastman Assemblies for 1-wire braid hose.

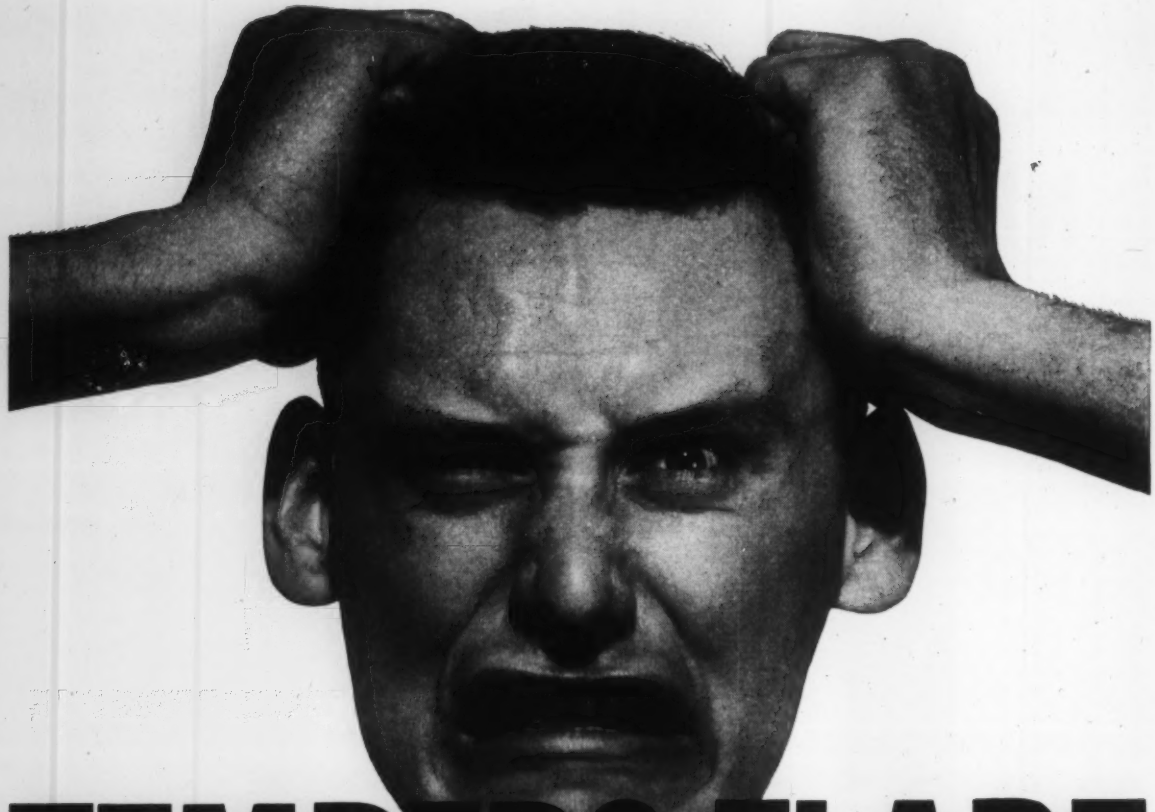
Please send me.....copies of Bulletin 200 on High Pressure Eastman Assemblies for 2-wire braid hose.

Also.....copies of Bulletin 500 on Adapters and Adapter Unions.

Name _____ Title _____

Company _____

Address _____



TEMPERS FLARE

when strip-outs cause re-do's!

"Take any operation where assemblers must match-up tapped holes, avoid cross-threading, and drive machine screws into place—and you could be sitting on dynamite.

"When strip-outs occur (and they will), work stops or the piece must be removed from the line. The hole must be enlarged, re-tapped, a larger screw used, and you know what this means to employees working under a bonus plan.

"Or take the case of our *Portagraph* units," says MR. E. G. LAYER, ENGINEERING SUPERVISOR AT REMINGTON RAND SYSTEMS DIVISION IN TONAWANDA, N. Y. "Here, where plastic sockets are mounted, assemblers had to hold nuts in place under a steel sheet while screws were driven down from above. Get on the receiving end of bitter complaints about cut and bruised fingers, and you start looking for a better solution in a hurry."

The solution to both problems was simple. When Remington Rand switched to PARKER-KALON SELF-TAPPING SCREWS, these labor grievances quickly disappeared. If you'd like advice on proper types of fasteners for your product, a Parker-Kalon Field Engineer will be glad to be of assistance.

For light and heavy gage metals, ferrous and non-ferrous castings, bronze and brass forgings, structural steels, resin impregnated plywoods, woods, asbestos compositions, and plastics of all kinds, specify . . .

PARKER-KALON®
Self-tapping Screws

Sold everywhere through leading Industrial Distributors.

PARKER-KALON DIVISION, *General American Transportation Corporation, Clifton, New Jersey*

ENJAY BUTYL

creates a world of quiet in new Imperials

Enjay Butyl adds to the comfort and enjoyment of new Imperials in two important ways: by sealing out sound *and* weather. Enjay Butyl is ideal for applications involving exposure to sun and weather, for Butyl is highly resistant to heat, sunlight, aging and ozone. Butyl also offers outstanding resistance to chemicals, abrasion, tear and flexing... superior damping properties... unmatched impermeability to gases and moisture. Tough, low-cost Butyl is the right rubber for many varied uses. Find out how this versatile product can improve your product.

For complete information...
write or phone your nearest Enjay office. Enjay's extensive laboratories and expert staff are always glad to provide information and technical assistance.

EXCITING NEW PRODUCTS THROUGH PETRO-CHEMISTRY

ENJAY COMPANY, INC.
15 West 51st Street, New York 19, N. Y.
Akron • Boston • Charlotte • Chicago • Detroit • Los Angeles • New Orleans • Tulsa

ENJAY® BUTYL

Circle 490 on Page 19

ANOTHER IN A SERIES
OF MOTOR FACTS
FROM ALL INDUSTRIES

"Roughest duty we have ever seen motors endure"

reports Marquette Iron Mining Co. of the Westinghouse Life-Line A motors in its Eagle Mills Pelletizing Plant

Operating continuously, 24 hours per day, dependable Westinghouse Life-Line® "A" motors drive a network of fans and conveyors at the Eagle Mills Pelletizing Plant of Marquette Iron Mining Co., Ishpeming, Michigan.

Some of these motors are located directly above a sintering machine where ambient temperatures often exceed 200° F and the motor is subjected to deposits of finely divided iron ore. Under these conditions, not a single motor breakdown or failure has occurred during 11 months of service.

Says Mr. Ed Gagnon, plant electrician, "Our Westinghouse motors have given us complete reliability on the roughest tests we have ever seen a motor endure."

For specific information about the ways your operation can benefit from the improved performance, longer life and reduced maintenance offered by the dependable Life-Line "A," contact your nearby Westinghouse sales engineer. Or write to Westinghouse Electric Corporation, P.O. Box 868, 3 Gateway Center, Pittsburgh 30, Pennsylvania. J-22077

YOU CAN BE SURE...IF IT'S Westinghouse

Deposits of powdered iron ore are no problem to this 2-hp Life-Line "A" motor driving conveyor which carries powdered iron ore to the balling disc where ½" pellets are formed. Presealed, prelubricated Life-Line "A" bearings keep dirt and other material out.

Circle 491 on Page 19

Impact resistance—The image of impact can take many forms. To a train-conscious youngster, impact might be the crash-coupling of freight cars. To the contour miner, impact is a mammoth dipper smashing into frozen highwall. To the ordnance man, impact is a shell striking armor plate. Whatever the image, impact implies one thing—toughness.

Toughness is the ability to absorb energy—to "give" under a shock load without fracturing. This property—toughness—in steel, more than in any other material, has been vital to the building of the modern world. Steel's ubiquitous role, however, belies the complexity of toughness. Because just as there are many kinds of steel, so there are many degrees of toughness, and a given steel's toughness is shaped by the admixture of its composition, manufacture and fabrication.

The design engineer, if he is to do his job well, must know his toughness in order to select the right steel for the job. He must know something of how toughness is achieved, because this often can result in using less expensive steels. The geometry of a part or structure is also important to its toughness, and here the designer reigns supreme.

In steelmaking, toughness and strength are determined by composition and manufacturing steps. Often, as is the case with USS* "T-1" Constructional Alloy Steel, a very high level of strength and toughness is obtained through selection of alloying elements and by proper heat treatment. The steelmaker can help you obtain the best combination of strength and toughness along with other desirable properties like weldability, corrosion resistance, formability and wear resistance. He can also recommend post-fabrication heat-treating practice where it is required to develop mechanical properties or relieve stress in fabricated assemblies.

Clearly, toughness is complex. But for any application, there is one best steel no matter what combination of properties you need. You are almost certain to find that steel among the great family of USS Design Steels: Carbon, High Strength, Alloy and Stainless. Our experience is yours for the asking. Write United States Steel, 525 William Penn Place, Pittsburgh 30, Pa. You'll find our nearest representative in the Yellow Pages listed under United States Steel.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS *TRADEMARK **United States Steel**

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

STEELS FOR OPEN

Lower Left—Problem: Design dump cars for tunnel excavations to remove rock. Must have high impact resistance, plus corrosion resistance to withstand alternate wetting and drying. Solution: Build cars from USS COR-TEN* High Strength Steel. Pay-off: Cars take minimum maintenance, have been in continual service for six years, and are still in excellent condition.

Lower Middle—Problem: Design a 60 cu. yd. shovel that could take the terrific abuse of all-weather overburden removal. Solution: Bucket, bail, dipper stick and crowd rack built entirely of welded USS "T-1"* Steel, a constructional alloy steel having exceptional toughness at below zero temperature and which can be field-welded and flame-cut. Pay-off: Outstanding performance in 7-day-a-week, 24-hour-a-day service with minimum maintenance.

Lower Right— Problem: Design a tank to hold the liquid equivalent of 10 million cubic feet of oxygen at 300°F. below zero. Solution: Tank was designed with impact-resistant austenitic USS Stainless Steel. Pay-off: Tank can withstand sudden changes of pressure, temperature changes and volume at low temperatures that would shatter other materials.

The Panelbuilder

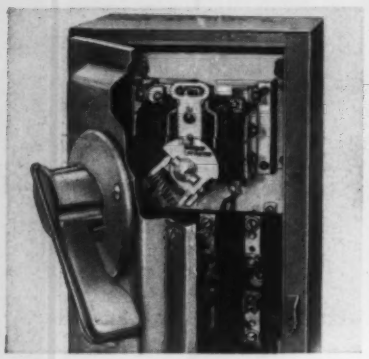
87 YEARS OF SERVICE
CUTLER-HAMMER
CONTROL
C-H

News for and about Panelbuilders

Cutler-Hammer Inc., Milwaukee, Wis. • *Division:* Airborne Instruments Laboratory. • *Subsidiary:* Cutler-Hammer International, C. A.
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation.

CUTLER-HAMMER MOTOR DISCONNECT SWITCH SIMPLIFIES PANEL ASSEMBLY

Panelbuilders using the Cutler-Hammer 10904 Motor Disconnect Switch report it provides important savings in time and effort in the assembly of their control panels. The complete unit consists



3/16" radial adjustment of the cover mounted mechanism assures correct alignment with panel mounted disconnect switch.

of a contactor type disconnect switch mechanism, adjustable operating shaft, cover interlock, and external operating mechanism. The switch mechanism uses the same basic structure of the famous Cutler-Hammer Three-Star Contactor, and is easily panel mounted and wired. To mount the external operating handle mechanism, five holes are drilled in the cover following template directions provided with each unit. Exact alignment of these mounting holes with respect to the switch mechanism isn't critical. Compensation for misalignment is provided through the operating handle mechanism's 7/16" radial adjustment. The Cutler-Hammer 10904 Motor Disconnect Switch can be used in any enclosure where the panel-to-cover depth is between 5¾" and 20¾". External operating mechanisms are also available for type F, G, J, K, KL, and L circuit breakers. For further information write for Bulletin 10904-D-243. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

CONTROL PANEL CORPORATION SUPPLIES HYDRAULIC PRESSURE GENERATOR CONTROL

One of thirty hydraulic pressure control units supplied by the Control Panel Corporation equipped with Cutler-Hammer Components.

During the past five months the Control Panel Corporation of Chicago, Illinois, has supplied a large number of these compact, NEMA 12 enclosed hydraulic pressure generator control units. The control units are used in conjunction with high speed riveting on a mass production assembly line. Typical of the control equipment used on high volume production machinery, every effort was made in the choice of the components to insure dependable, trouble-free operation.

Mr. H. A. Hart, President of the Control Panel Corporation, reports: "It has been our experience the proper performance of any machine powered by electric motors depends directly upon the control equipment used . . . no machine can be more dependable than the

Mr. H. A. Hart

control which directs and protects it. This is why we and many of our customers consider a component's record of performance an important factor when selecting the components to be used in the controls we supply."

PANEL BUILDERS HANDBOOK SIMPLIFIES SELECTION OF ELECTRICAL COMPONENTS

This handy 70 page reference guide is specifically edited to assist design engineers and control panelbuilders in the selection of electrical control components and control accessories. Every effort was made to make this book as concise as possible, and yet it includes such vital information as wiring diagrams, dimension drawings, ratings, ordering information, and a maintained price list. Address your request for your personal copy of Bul. EE120-D243 on your company letterhead. Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Circle 492 on Page 19

MACHINE DESIGN
February 19, 1959

Lemons and Sour Notes

PROUD ownership of one of Detroit's sleek new dream cars quickly faded to sad disillusion. The transmission conked out after only 6000 miles of conservative driving.

More in sorrow than in anger Joe tackled the dealer, only to be told that the warranty expired at 4000 miles. "So the transmission isn't expected to last more than 4000 miles?"

"Not at all," countered the dealer, "it's designed for 100,000 miles."

"In other words," Joe observed, "I've got a lemon."

In shocked tones the dealer denied any such possibility. But nothing could be done to adjust the matter and Joe seems to be stuck with a $400 bill.

Of course he had a lemon. And the appearance of lemons in much of today's hardware—cars, appliances, weapons—is so commonplace that it is almost taken for granted. Except by the affected customer, of course.

We've learned a wonderful new method of rationalization—hiding behind the mathematical concept of reliability. We multiply together the separate reliabilities of each component of a complex machine and console ourselves with the thought that 99 per cent reliability is pretty good considering how high each individual reliability must be to attain that figure.

But it isn't good enough for the one Joe in a hundred who gets the lemon. Nor would it be for the inhabitants of the city hit by a nuclear warhead after the one-hundredth antimissile missile failed in its mission.

Mechanical reliability is inseparable from human reliability. Back of most equipment failure lies some human error, carelessness, incompetence—maybe even laziness. The unreliable factor could be a researcher, a development or design engineer, a machinist, an inspector—almost anybody in the outfit.

An organization's tolerance of human lemons is the key to control of lemons in the output. So long as each individual keeps his personal reliability under tight control, overall reliability will be high.

Is a Heifetz satisfied with "only" one sour note in a hundred, or even a million? Not likely; he's a professional.

Colin Carmichael

EDITOR

Beauty is more than skin deep in a well-made product model. Full-scale replicas of products can not only look like the real thing, but can also have actual operating features. This article gives pointers on model materials, cost, weight, durability, and other factors that help decide . . .

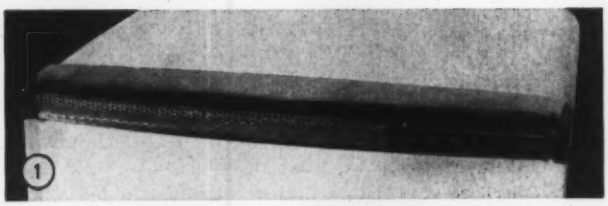
WHICH PRODUCT MODEL TO BUILD

By MONTGOMERY FERAR
Sundberg-Ferar Inc.
Detroit, Mich.

A model is created . . .

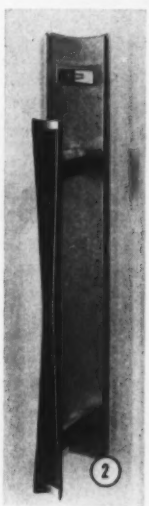
APPEARANCE models can be important adjuncts to the design of industrial and consumer products. They often help in troubleshooting the design, gaging production requirements, and aiming sales programs. Instead of translating directly from an industrial designer's renderings or sketches to engineering drawings, an intermediate step is added—model building.

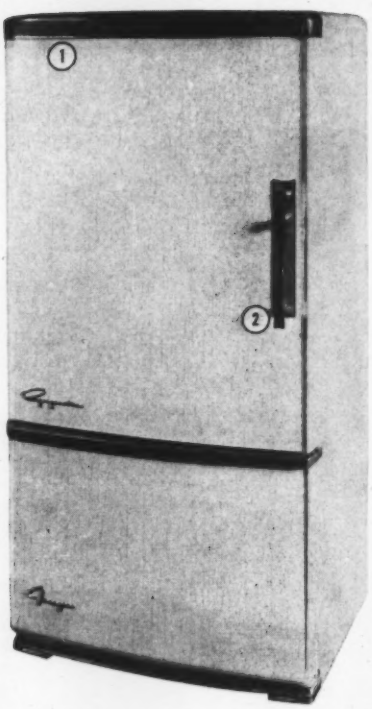
The kind of model to use, obviously, depends upon its purpose. Models can be constructed of clay, wood, glass-fiber reinforced plastic, vacuum-formed plastic, fabricated plastic, and metal. Quite frequently all six materials are used in a single model.



Door cap *is a zinc pressure casting from a wood pattern. Coldspot nameplate is engraved, gold-plated sheet brass.*

Handle assembly *is produced as a zinc pressure casting from a wood pattern.*



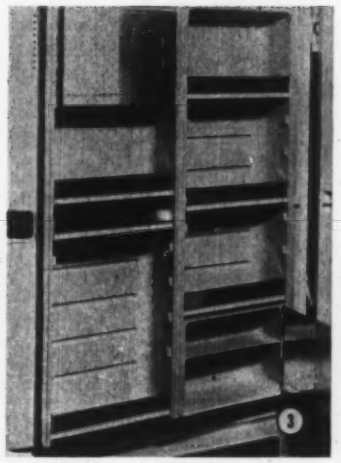


Main housing and door *of model for 1958 Coldspot refrigerator-freezer is made of wood to actual door and cabinet thickness. Multiple finish coats simulate porcelain-like finish on sheet metal. Nameplates on door are engraved in sheet brass, then chrome plated.*

Why Use Appearance Models?

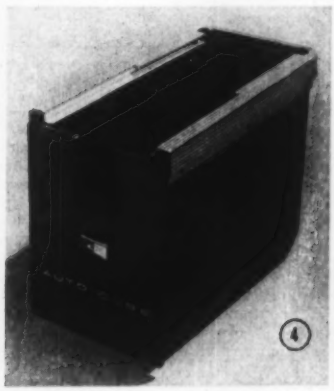
- *Help visualize the design in three dimensions.*
- *Perfect the development and blending of planes and curved surfaces.*
- *Make certain that housings provide necessary clearance over mechanical parts and assemblies.*
- *Visualize what is going to be required to produce the product as designed.*
- *Help plan sales strategy by creating a full line of appearance models as much as one year in advance of production.*
- *Provide photographic subjects for catalog and advertising illustrations months ahead of production.*
- *Furnish patterns accurate enough for either visual or keller models.*

. . . in wood, metal, plastic, paint

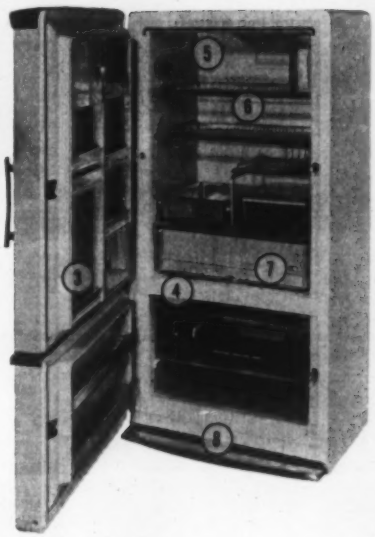


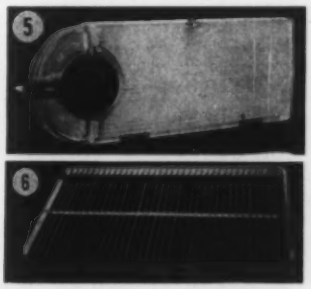
Inner door *is sheet plastic, vacuum-formed over a wood pattern to simulate production part. Dairy Chest and Snack Chest doors, and shelf fronts, are plated, hammer-formed sheet metal with etched patterns.*

Ice cube bin *is fabricated plastic. Ice-cube shucker is a zinc pressure casting.*

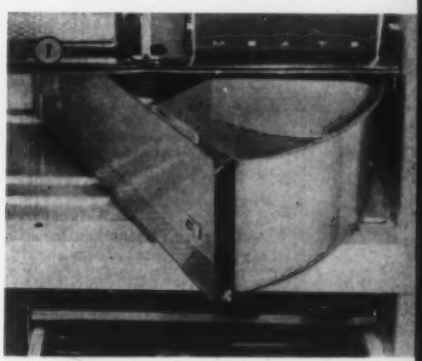


Thermostat and light fixture *is fabricated plastic.*



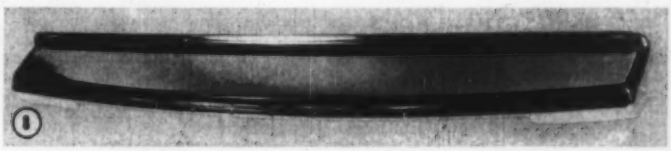


Wire tray *has hammer-formed outer frame section, extruded-metal front, with wires soldered in. Extrusions are used on other interior-shelving fronts.*



Rotary crisper *has a basket fabricated from sheet plastic and a hammer-formed front.*

Base plate *is hammer-formed and plated.*



Selecting Model Materials

Cost	Weight	Fabrication	Durability	Appearance	Modifications	Portability
Clay						
Low	Heavy	Easy	Poor	Good	Easy	For local showing
Wood						
Low to medium	Light to medium	Fairly easy	Good	Very good	Depends on fineness of detail	Can be transported
Glass-fiber reinforced plastic						
Medium to high	Light	Requires care and control	Usually excellent	Very good	Minor surface modifications possible	Easily handled and transported
Vacuum-formed plastic						
High, unless multiples are needed	Light	Fairly easy, if quality is high	Good	Good	Minor surface modifications; inserted patch areas	Easily handled and transported
Fabricated plastic						
High	Medium	Requires care and control	Fair	Good to excellent	Requires care	Requires careful handling and shipping
Metal						
Medium to high	Medium to heavy	Fairly easy to difficult	Good to excellent	Good to excellent	Depends on detail	Easily handled, transported

Clay

Quickest and easiest to use. Particularly good for visualizing a new form that involves three-dimensional contours. Models can be quickly changed by either increasing or reducing volume. Can be painted or used as molds for plaster models. Hard to transport since models are easily damaged.

Wood

Harder to build with and requires a more final design than clay. More difficult to add or subtract volume. Models can be very accurate and can be finished to look exactly like the production item. Easy to transport. Can be modified without too great difficulty. If model is made of hard wood, it can be used as mold for plaster models. Can be worked with enough dimensional accuracy for use as patterns for die casting and as keller models.

Glass-fiber reinforced plastic

Light and permanent, but difficult to change. Clay and wood models can be reproduced in glass-fiber reinforced plastic by casting plaster female forms, then using these as molds for the glass cloth and resin.

Vacuum-formed plastic

Especially valuable in duplicating a design once the model has been frozen and for showing colors and other features of a line. Model is formed by vacuum drawing a sheet of heated plastic over a wooden pattern. Containers and similar hollow parts can be produced that closely match production items in wall thickness and weight.

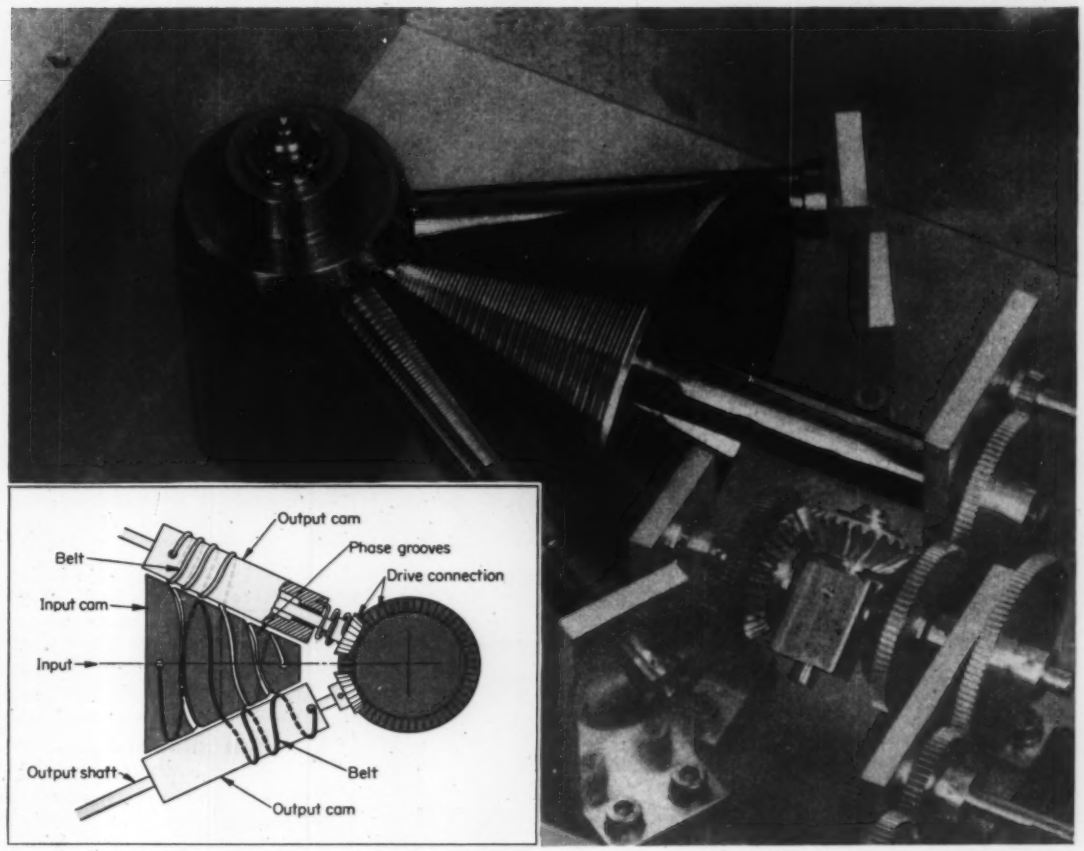
Fabricated plastic

Often employed to simulate molded plastic components. Models are assembled from plastic sheets or blocks cemented together. Care is necessary in fabrication, and special plastic paints must be used to prevent crazing.

Metal

Expensive, so usually used for certain parts of composite models to achieve finishes that closely reproduce appearance of actual finished product. Sheet metal can be formed into accurate compound curves by hammering over maple blocks. Metal models can be made in pieces and then welded or soldered together. Sand or pressure castings, using wood patterns, make beautiful models that are exact replicas of die-cast parts, but are expensive since the cast part must be hand buffed and plated. Castings are often used as trim pieces for a chrome or gold accent.

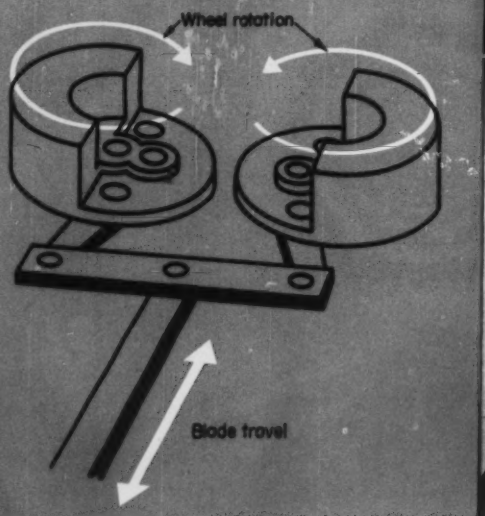
scanning the field for *ideas*

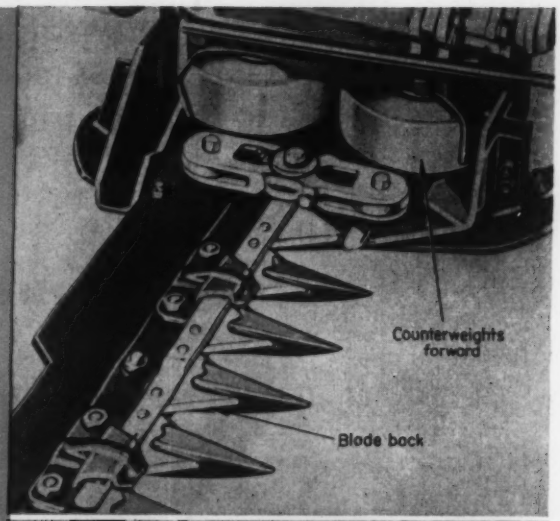


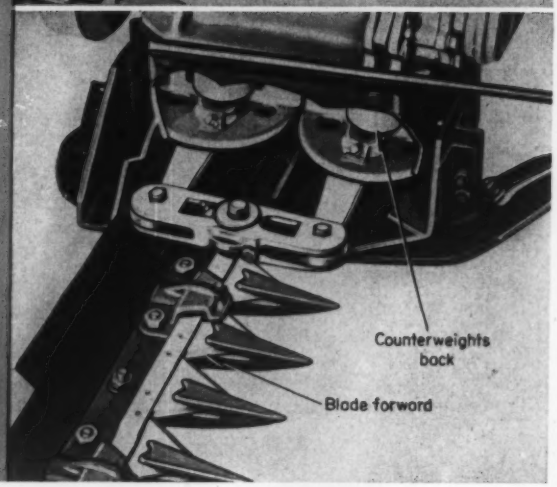
Double-wound belt drive eliminates errors and insures smooth operation of precision rotating parts in a mechanical function generator. Designed by Sigmund Rappaport* and William H. Newell, Ford Instrument Co., Div. of Sperry Rand Corp., the system employs two wire belts, separately wound in side-by-side grooves on the input cam surface. The two belts pass from the input cam onto two output cams, which are placed close to the input cam in a position that depends upon the phase offset of the grooves, and continue spirally in opposite directions. A spring-loaded drive connection between the output cams permits the output shaft to rotate in either direction and prevents slack in the idling wire belt. The mathematical ratio between the input and output shafts depends upon the solid of revolution configurations of the input and output cams. In the illustrated design, the output is proportional to the square of the input.

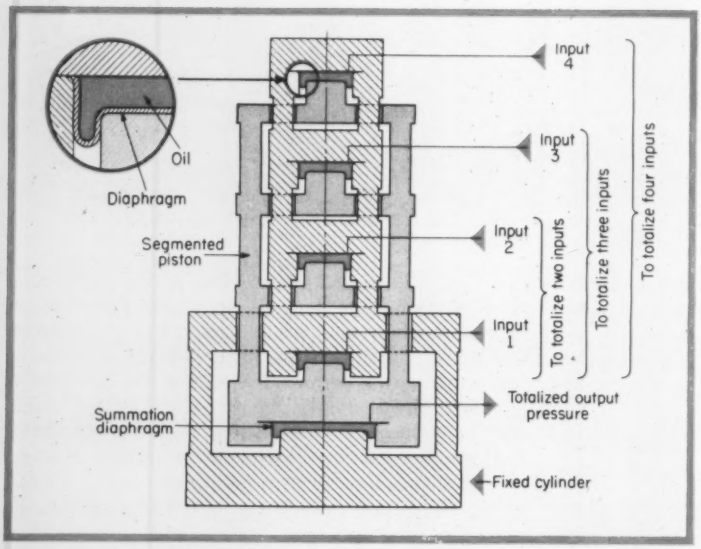
*Adapted from a paper presented by Sigmund Rappaport, also Adjunct Professor, Polytechnic Institute of Brooklyn, at the Fifth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 13-14, 1958.

Counterbalanced flywheels minimize vibration in a drive system which converts rotary to reciprocating motion. Employed in a mower design by Allis-Chalmers Mfg. Co., two half-disk flywheels rotate in opposite directions. As the wheels rotate, they create an unbalanced force that opposes the force developed by the reciprocating mower blade. Forces created perpendicular to the path of blade travel are cancelled out by the opposing action of the wheels.









Stacked diaphragms add independent hydraulic - pressure inputs to give an instantaneous totalized output. As source pressures are introduced into diaphragm cavities, each diaphragm exerts force on a face of a floating segmented piston. The base of the piston is sealed from a fixed cylinder by a hydraulic summation diaphragm, which converts the piston forces into a totalized pressure output. This principle is used in the Way-Pac Load Totalizer for load summations.

When an invention is used commercially or put up for sale, failure to file a patent application within a prescribed time period can cost the inventor his rights to a patent. Under the present law, this limitation is one year, although there are certain exceptions. Here is how the courts look at

Patents of Commercialized Inventions

By ALBERT WOODRUFF GRAY
Forest Hills, N. Y.

WOVEN into the patent statute and the decisions of the courts of this country is a rule of law laid down by the Supreme Court over a century and a quarter ago. The rule deals with selling or using an invention prior to application for a patent, either of which may be cause for an inventor's loss of his right to the patent. In a decision in 1829, Justice Story put forth a principle that has now become a part of the patent law. This principle was that, while an important object of granting patents is to reward inventors by giving them an exclusive though limited right to their inventions, to stimulate the efforts of genius, "the main object was 'to promote the progress of science and useful arts,' and this could be done best by giving the public at large a right to make, construct, use and vend the thing invented at as early a date as possible, having a due regard to the rights of the inventor."

The inventor of "an improvement in the art of making tubes or hose for conveying air, water and other fluids," had sold some 13,000 ft of this hose over a period of seven years before he applied for a patent. Later, when a suit for infringement was brought by him, the patent claim was held invalid because of this prior commercial use of the invention before application for the patent was made.

The inventor appealed to the Supreme Court; there Justice Story added to his comment on the purpose of the patent statute[1] the reasons underlying the prohibition against too long use of the invention before the granting of the patent:

"If the inventor should be permitted to hold back from the knowledge of the public the secrets of his invention, if he should for a long period of years retain the monopoly and sell his invention publicly and thus gather the whole profits from it, relying on his superior skill and knowledge of the structure and then, and then only, when the danger of competition should force him to secure the exclusive right, he should be allowed to take out a patent and thus exclude the public from any further use than what should be derived under it during his fourteen (now seventeen) years, it would materially retard the progress of science and the useful arts and give a premium to those who should be least prompt to communicate their discoveries."

A provision in the 1952 patent statute,[2] conveying the substance of Justice Story's comment, states:

[1]References are tabulated at end of article.

"A person shall be entitled to a patent unless . . . the invention . . . was in public use or on sale in this country more than one year prior to the date of the application for patent in the United States."

Loss of Patent Rights

Circumstances such as those condemned by the Supreme Court in that early decision were involved in a suit brought for the infringement of a patent for metallizing worn surfaces, a process described as "so conditioning a metal surface that the same is capable of bonding thereto applied spray metal to a higher degree than is normally procurable with hitherto known practices."

This process had been known for nearly 30 years, and two ways of producing such a surface had been developed—sand blasting and machining.

The process for which the patent had been issued was to prepare the surface by first depositing on it a preliminary layer of metal. This inventor, instead of roughening the base metal by mechanical means, used electrical means. Instead of merely roughening the metal of the base and applying sprayed metal directly, he interposed a layer of electrode metal fused to the base and having a metallic structure peculiarly suitable to bonding with the sprayed metal.

Application for a patent of this process was not filed by the inventor for nearly two and a half years after his discovery. When infringement action was brought by the inventor a few years later, the defense was based on prior use, which under this provision of the statute forfeits the inventor's right to a patent.

Grounding its conclusion on the early Supreme Court decision, the federal court held that the inventor had invalidated his patent and no infringement action would lie for the use of the process by others. The court said:

"It is a condition upon an inventor's right to a patent that he shall not exploit his discovery competitively after it is ready for patenting. He must content himself with either secrecy or legal monopoly. It is true that for the limited period of two years he may do so, possibly in order to give him time to prepare an application and even that has been recently cut down by half. But if he goes beyond that period of prohibition he forfeits his right regardless of how little the public may have learned about the invention, just as he can forfeit it by too long concealment even without exploiting the invention at all."

Then of the exception to this rule, the federal court[3] added,

"It is indeed true that an inventor may continue for more than a year to practice his invention for his private purposes or his own enjoyment and later patent it. But that is, properly construed, not an exception to the doctrine, for he is not then making use of his secret to gain a competitive advantage over others. He does not thereby extend the period of his monopoly."

Public or Private Use?

In New York, suit had been brought for the infringement of a patent on an improvement of a woman's corset-springs. In support of the defense of a prior use it was shown that the inventor had presented a woman with a pair of these springs. Three years later he gave her another pair. But the patent for the springs was not issued until eleven years later.

When this feature of the infringement suit came before the Supreme Court[4] for review, it was held that here was an instance of prior public use fatal to the validity of the patents claimed to be infringed.

"To constitute the public use of an invention it is not necessary that more than one of the patented articles should be publicly used. The use of a great number may tend to strengthen the proof but one well defined case of such use is just as effectual to annul the patent as many.

"For instance, if the inventor of a mower, a printing press or a railway-car makes and sells only one of the articles invented by him and allows the vendee to use it for two years without restriction or limitation, the use is just as public as if he had sold and allowed the use of a great number.

"We remark secondly that whether the use of the invention is public or private does not necessarily depend upon the number of persons to whom its use is known. If the inventor, having made his device, gives or sells it to another to be used by the donee or vendee without limitation or restriction, or injunction of secrecy, and it is so used, such use is public even though the use and knowledge of the use may be confined to one person."

Public Good

Many years ago a suit was brought against an electrical-parts manufacturer for what was claimed to be an infringement of a "method and batch or mixture for making glass for illuminating purposes as in electric and other shades and globes." For ten years a glass manufacturer had used in secret a process for making illuminating glass. During that period products of this formula had been sold in large quantities in the trade.

At the end of this ten-year period application had been made for a patent on this process, and the patent was issued. When, a short time later, suit for infringement of this patent was brought, the federal court[5] refused to sustain the validity of the patent. With a reference to the provision granting the patent monopoly to an inventor for 17 years, the federal court said:

"When a patent expires, the right to practice the invention thus becomes available to everybody.

The object of such a limitation and disclosure was to secure to the public the full benefits of patented objects as speedily as was consistent with reasonable stimulation of invention.

"If then we assume that the course adopted by the present inventor and his assignee did not contemplate an intent to abandon the right to secure a patent, it certainly did contemplate an indefinite delay in disclosure of the invention and substantial enlargement of any period of monopoly recognized by the statute. Can it be added that this was opposed to the declared and subsisting public policy."

Testing Period

Restrictions on the application of the words, "in public use or on sale in this country" in the 1952 patent statute, however, exclude from the prohibition of the statute the testing or development of an invention for which later a patent may be sought. This feature is sharply outlined in a suit, brought against a city for the infringement of a patent for wooden pavement, that ultimately came before the Supreme Court.

In its defense, the city contended that this wooden pavement invention had been in public use for six years before the application for a patent had been filed. This contention was met by the inventor with the assertion that the use of the pavement prior to the application for the patent had been for the purposes of testing the efficiency of the invention.

The court held[6] that the city was liable for infringement of the patent. Regarding the extent to which the testing and trial of inventions may be conducted without a violation of the patent statute, the court said:

"It is not a public knowledge of his invention that precludes the inventor from obtaining a patent for it, but a public use or sale of it. It is sometimes said that an inventor acquires an undue advantage over the public by delaying to take out a patent inasmuch as he thereby preserves the monopoly to himself for a longer period than is allowed by the policy of the law, but this cannot be said with justice when the delay is occasioned by a bona fide effort to bring his invention to perfection or to ascertain whether it will answer the purpose intended.

"His monopoly only continues for the allotted period in any event and it is in the interest of the public as well as himself that the invention should be perfect and properly tested before a patent is granted for it. Any attempt to use it for a profit and not by way of experiment for a longer period than two years (now one year) before the application would deprive the inventor of his right to a patent."

This statement of the law outlining the latitude available to an inventor for the testing of a discovery was supplemented a few years later by this same court[7] in a decision involving the same feature of the patent law.

"A use by the inventor for the purpose of testing the machine, in order by experiment to devise additional means for perfecting the success of its operation, is admissible. And where, as incident to such use, the production of its operation is disposed of by sale, such profit from its use does not change its character. But where the use is mainly for the purpose of trade and profit and the experiment is merely incidental to that, the principle and not the incident must give character to the use.

"The thing implied as excepted out of the prohibition of the statute is a use which may properly be characterized as substantially for purposes of experiment. Where substantial use is not for that purpose but is otherwise public and for more than two years prior to the application, it comes within the prohibition."

REFERENCES

1. Pennock v. Dialogue, 27 *U. S.* 1, January, 1829.
2. 35 U.S.C.A., Sec. 102(b).
3. Metallizing Engineering Co. v. Kenyon Bearing & Auto Parts Co., 153 *Fed.* 2d 516, Connecticut, January 10, 1946.
4. Egbert v. Lippmann, 104 *U. S.* 333, New York, October, 1881.
5. Macbeth-Evans Glass Co. v. General Electric Co., 246 *Fed.* 695, Ohio, November 6, 1917.
6. Elizabeth v. Pavement Co., 97 *U. S.* 126, New Jersey, October, 1877.
7. Smith & Griggs Mfg. Co. v. Sprague, 123 *U. S.* 249, Connecticut, November 14, 1887.

Tips and Techniques

Determining Function Values

The value of a function, such as $2x^4 - 3x^3 + 5x^2 - 4x + 2$, for a particular value of x is found quickly by this procedure.

1. Set down the coefficients and the independent term.
2. Multiply the first coefficient by the required value of x and add the product to the next coefficient.
3. Multiply this sum by the value of x, and add the product to the independent term, or to the next coefficient when there are more than two terms containing x. The value obtained in the last addition is the value of the function for the value assigned to x.

Example: Find the value of $2x^4 - 3x^3 + 5x^2 - 4x$ if $x = 4$.

2	−3	+ 5	− 4	+ 2
	+8	+20	+100	+384
	+5	+25	+ 96	+386

Hence, the value of the function is 386.—F. MURRAY, *Chicago, Ill.*

Do you have a helpful tip or technique for our other readers? You'll receive ten dollars or more for each published contribution. Send a short description plus drawings, tables, or photos to: Tips and Techniques Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, O.

Replacing "cut and try," here's a rational method for designing complex hydraulic circuits.

1. Determine required circuit outputs.
2. Write logic equations for desired outputs.
3. Simplify equations.
4. Select components to fulfill output requirements.

Borrowed from computer-circuit design, the fundamentals of AND, OR and NOT functions and their application in circuit synthesis are outlined in the first installment of this article. The use of circuit components and elements as special logic functions will be discussed in the concluding part.

(a) AND Circuit: Normally closed valves in series. To connect P to T, all valves are opened at same time. Thus, flow from P to T is permitted if valve A and valve B and valve C are open. The equation is

$$f(P \text{ to } T) = A + B + C \qquad (1)$$

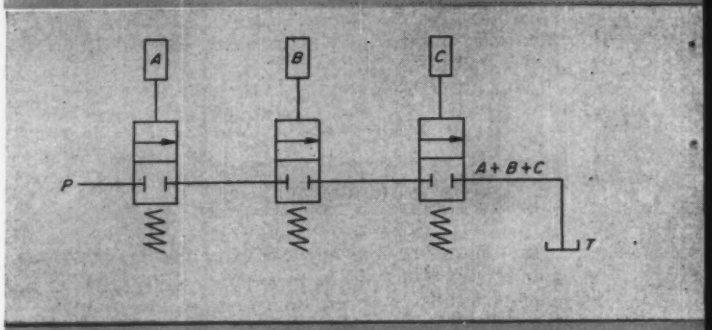


Fig. 1—Basic logic functions

HYDRAULIC SWITCHING CIRCUITS

By **HAROLD R. RONAN JR.**
Research Engineer
Gould and Eberhardt Inc.
Irvington, N. J.

CREATION of complex hydraulic control systems is no mean task. Although individual circuit components are simple, their interrelation in a large network is not. System design often bogs down in small details which, though important to the operation of the circuit, are not directly related to the over-all objective.

Thus, the designer of complex circuits needs a tool which will permit him to envisage combinations of circuit elements that yield desired outputs and are consistent with reliability, safety, and cost restrictions. Logic functions, Fig. 1, are the fundamentals of an approach that does this job.

Function Combinations

Once these logic-function concepts are understood, they can be combined and applied in rational design procedures. The best way to illustrate the combination of functions is to assume an equation for a circuit and draw the corresponding piping diagram.

For example, from the notations for AND and OR functions, Fig. 1,

$$f(P \text{ to } T) = A + BC + EDB \qquad (4)$$

To connect P to T, Equation 3, Fig. 1, states that A plus (B or C), plus (E or D or B) must be energized.

Fig. 2*a* shows that if A and B are energized, P is connected to T. Hence, if the two valves representing B are removed, and one valve B is added in parallel with $C+ED$, Fig. 2*b*, none of the conditions have been changed, but one valve has been eliminated. Equation 4 reveals that B was simply factored out by this manipulation, and the equation becomes

$$F(P \text{ to } T) = A + B(C + ED)$$

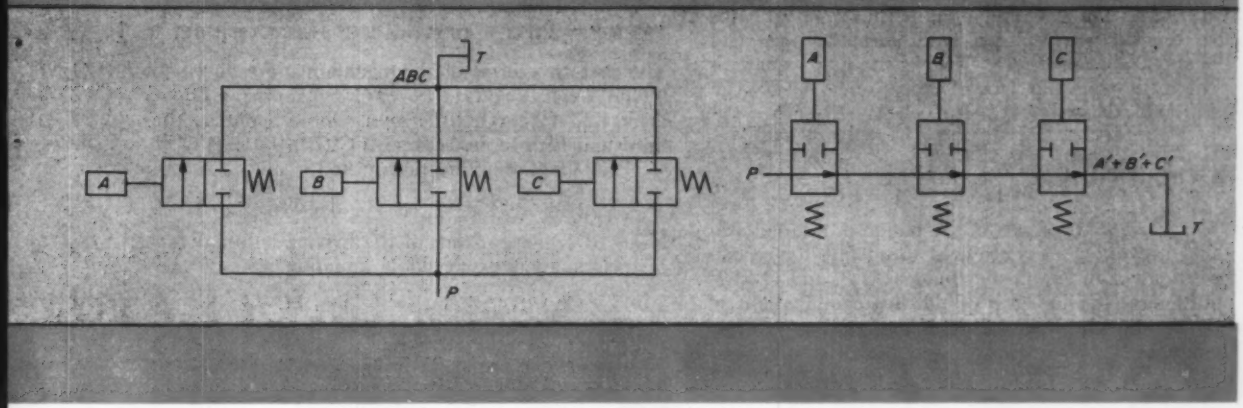
A second example, Fig. 3, shows further how these functions are used to simplify circuitry. The equation for this piping diagram is $f(P \text{ to } T) = A(A+B)$. The conditions of closure indicate that if A is ener-

(b) OR Circuit: Normally closed valves in parallel. To connect P to T only one valve is opened. Thus, flow from P to T is permitted if valve A or valve B or valve C is open. If multiplication represents OR, the equation is

$$f(P \text{ to } T) = ABC \quad (2)$$

(c) NOT Circuit: Basically same arrangement as in a with normally open instead of normally closed valves. Connection of P to T is possible only if A, B, and C are not present. Instead of minus signs, prime marks are used to indicate a closed path when an element is missing. The equation is

$$f(P \text{ to } T) = A' + B' + C' \quad (3)$$



Part 1—AND, OR, and NOT Logic Functions: Efficient design tools for synthesizing complex hydraulic circuits.

gized, P to T is connected regardless of the state of B. Hence, B is unnecessary, and the equation reduces to $F(P \text{ to } T) = A$.

Theorems: To facilitate the synthesis procedure, a set of theorems which indicate basic truths about switching paths can be tabulated, Table 1. To check the validity of any switching equation, all combinations of the elements must be investigated to show that both sides of the equality yield the same output. To facilitate this computation, a number of flow truisms are tabulated in Table 2.

First, all possible condition combinations of A, B, and C are determined and set down. Then, each of these combinations is taken in order and appropriate statements, Table 2, are applied to make both sides of the equation, Table 1, yield the same output.

To illustrate the use of these truisms, statements of Table 2 are used to prove Equation 1.4, Table 1. Results of this analysis are shown in Table 3.

Table 1—Switching Equations

Equation	Number
$A + B = B + A$	1.1
$AB = BA$	1.2
$AB + AC = A(B + C)$	1.3
$(A + B)(A + C) = A + BC$	1.4
$A + A = A$	1.5
$AA = A$	1.6
$A + AB = A$	1.7
$A(A + B) = A$	1.8

NOT Relationships: A number of basic truths involving NOT or negative relationships are found in Table 4. Although the meaning of a negative or NOT element is not difficult to comprehend, it has a subtlety which is not immediately obvious.

Consider the circuits shown in Fig. 1*b* and 1*c*. Note that in Fig. 1*b* the three normally closed valves are in parallel, while in Fig. 1*c* the three normally open valves are in series. They appear to be, and are

in fact, exact opposites. If the state of P to T for every combination of A, B, and C is determined for each of these circuits, it is found that the path in Fig. 1c is open for all combinations when the circuit in Fig. 1*b* is closed. The converse is also true.

When this condition is true, these two circuits are said to be duals of one another. To construct the dual of any circuit, parallel connections are replaced with series and conversely, and normally closed paths or elements are replaced with normally open elements and conversely. Two switching equations which illustrate this type of process are $(A+B+C)' = A'\cdot B'\cdot C'$ and $(A\cdot B\cdot C)' = A'+B'+C'$.

Circuit Problems

Suppose that, as part of the design of a larger system, a cylinder D is required to operate for certain positions of three other cylinders, A, B, and C. If D must move up for each of the five combinations of A, B, and C, then the statement of the problem might be

D	A	B	C
up	up	up	down
up	down	up	down
up	up	up	up
up	up	down	up
up	down	up	up

If down is assumed to be the negative of up, the switching equation which represents the requirements is

$$f(D) = (A + B + C')(A' + B + C') \times (A + B + C)(A' + B + C)(A + B' + C) \quad (5)$$

Table 2—Flow Truisms

Statement	Equation	Number
Free flow in parallel with free flow = free flow.	$0 \cdot 0 = 0$	2.1
Free flow in series with free flow = free flow.	$0 + 0 = 0$	2.2
Blocked flow in parallel with blocked flow = blocked flow.	$1 \cdot 1 = 1$	2.3
Blocked flow in series with blocked flow = blocked flow.	$1 + 1 = 1$	2.4
Blocked flow in parallel with free flow = free flow.	$1 \cdot 0 = 0 \cdot 1 = 0$	2.5
Blocked flow in series with free flow = blocked flow.	$0 + 1 = 1 + 0 = 1$	2.6
Output of circuit with free flow in series with element A = state of A.	$0 + A = A$	2.7
Output of circuit with free flow in parallel with element A = free flow.	$A \cdot 0 = 0$	2.8
Output of circuit with element A in series with a blocked circuit = a blocked circuit.	$A + 1 = 1$	2.9
Output of circuit with element A in parallel with a blocked flow = state of A.	$A \cdot 1 = A$	2.10

0 = free flow, 1 = blocked flow, and A = circuit element

General Approach: Equation 5 is much too complicated to use directly for a circuit and may be simplified by using the basic relations in Tables 1, 2, and 4. The first step is to take the negative of the equation, since it is easier to work with a sum of products rather than a product of sums. After simplifying the dual, the negative of the result is taken to obtain the desired solution.

Hence, for this problem, the negative of Equation 5 is

$$[f(D)]' = A'B'C + AB'C + A'B'C' + AB'C' + A'BC'$$

The first two terms of this equation are reduced to $B'C(A'+A) = B'C\cdot 1 = B'C$ by applying Equations 1.3, 4 2, and 2.10. In a similar manner, the third and fifth terms become $A'C'(B'+B) = A'C'\cdot 1 = A'C'$. These simplifications yield

$$[f(D)]' = B'C + A'C' + AB'C'$$

Next, B' is factored out of the first and third terms of this equation by virtue of Equation 1.3.

$$[f(D)]' = B'(C + AC') + A'C'$$

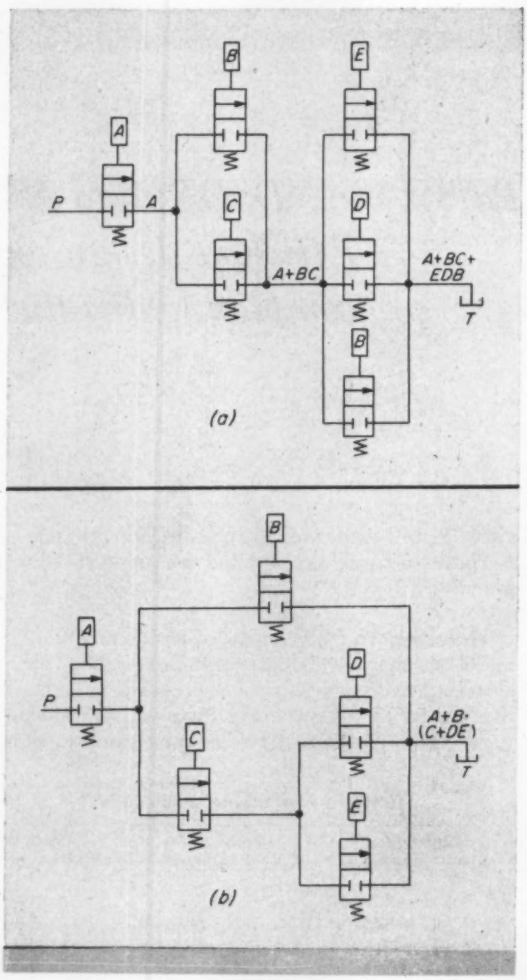


Fig. 2—Combinations of AND and OR elements. Circuits show, *a*, unsimplified and, *b*, simplified combinations to perform the same operation

Table 3—Typical Equation Proof

Condition of Elements A B C	Left Side of Equation $(A + B)(A + C) =$	Right Side of Equation $A + BC$	Statements of Table 2 Used For Proof
1 1 1	$(1 + 1)(1 + 1) = 1$	$1 + 1 \cdot 1 = 1$	2.3, 2.4
1 1 0	$(1 + 1)(1 + 0) = 1 \cdot 1 = 1$	$1 + 1 \cdot 0 = 1$	2.4, 2.6, 2.3, 2.5
1 0 1	$(1 + 0)(1 + 1) = 1 \cdot 1 = 1$	$1 + 0 \cdot 1 = 1$	2.4, 2.6, 2.3, 2.5
1 0 0	$(1 + 0)(1 + 0) = 1 \cdot 1 = 1$	$1 + 0 \cdot 0 = 1$	2.6, 2.3, 2.1
0 1 1	$(0 + 1)(0 + 1) = 1 \cdot 1 = 1$	$0 + 1 \cdot 1 = 1$	2.6, 2.3
0 1 0	$(0 + 1)(0 + 0) = 1 \cdot 0 = 0$	$0 + 1 \cdot 0 = 0$	2.1, 2.6, 2.2, 2.5
0 0 1	$(0 + 0)(0 + 1) = 0 \cdot 1 = 0$	$0 + 0 \cdot 1 = 0$	2.1, 2.2, 2.6, 2.5
0 0 0	$(0 + 0)(0 + 0) = 0 \cdot 0 = 0$	$0 + 0 \cdot 0 = 0$	2.1, 2.2

0 = free flow, 1 = blocked flow

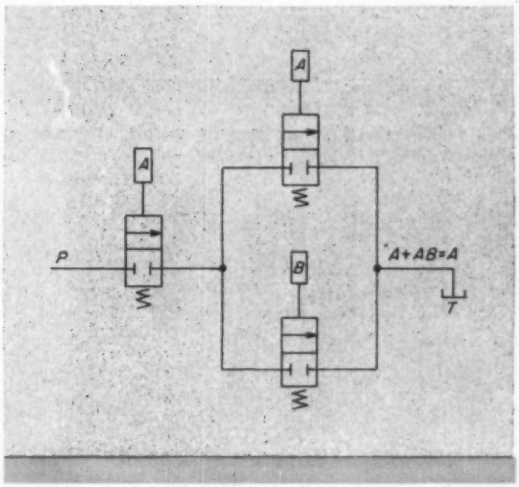


Fig. 3—Application of switching equations. Valve *B* in circuit is unnecessary

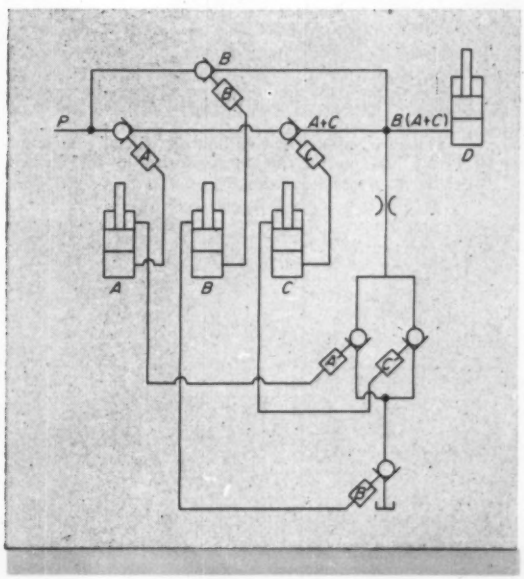


Fig. 4—Synthesis of circuit with check valves. Cylinder *D* motion is indicated by $f(D)=B(A+C)$

Table 4—NOT Function Equations

Statement	Equation	Number
NOT *A* in parallel with element *A* = a closed circuit.	$A' \cdot A = 0$	4.1
NOT *A* in series with element *A* = a blocked path.	$A' + A = 1$	4.2
NOT NOT element *A* = *A*.	$(A')' = A$	4.3
	$(A + B')B = AB$	4.4
	$AB' + B = A + B$	4.5

From Equation 4.5, $C+AC' = C+A$, and the equation further reduces to

$$[f(D)]' = B'(A + C) + A'C'$$

Since $A'C'$ is the negative of $(A+C)$, Equation 4.5 is again applied, and the negative is taken to give the final equation

$$f(D) = [[f(D)]']' = [B' + A'C']' = B(A + C) \qquad (6)$$

Component Selection: There are numerous components that could represent Equation 6. The choice depends primarily on conditions not related to the logic of the circuit. Consider the circuit, Fig. 4, in which oil from cylinders *A*, *B*, and *C* is for pilot purposes only and isolates the power circuit of *D* from the three cylinders. The statement of the problem implies that each of the cylinders *A*, *B*, and *C* should complete a full stroke before any signal is obtained. To obtain a pressure rise for signal purposes in a cylinder at the end of its stroke, none of the following arrangements can be used:

1. Any circuit which uses a pressure compensated pump and cylinder. Loads require operation in region where pressure is relatively constant for all volume outputs.
2. Any cylinder which uses a pressure-compensated, meter-out speed control in conjunction with a constant displacement pump and relief valve combination. Speed-control circuits require only a portion of the pump delivery, hence the relief valve must open and allow the unused oil to return to tank. While the cylinder is in motion the system pressure will effectively be at the relief valve setting.

Note also the circuit which shunts the logic circuit. This was introduced to return the piston of

cylinder D when it was not required to be up. This is the dual of the energizing circuit and takes advantage of an inherent property of a dual: A free-flow path for all combinations for which the negative is blocked.

Another circuit, Fig. 5, has the advantage of fewer components, but has a characteristic which may or may not be objectionable. If B is not present and C is present, the pressure line is connected directly to tank. If the pressure line is blocked by other means during this combination, or if it never occurs, this circuit could be used with no difficulty, provided there are no meter-out circuits. If a meter-out circuit is required, cam-operated valves, which function as limit switches, could be used.

The function D need not represent a cylinder only. In Fig. 6, the logic function represents flow to a line which could be connected to most anything. This circuit uses two sequence valves to represent $B(A+C)$. One of the sequence valves performs a double function; a remote pilot connection permits the valve to be used as a summing device. The valve is set so that it will not open unless there is proper pressure present at the inlet and pilot connections. Also, there is no isolation from the control cylinders as there was in the previous examples.

Complex Example: By the foregoing approach, more complex combinations may be reduced to relatively simple circuits. Consider a problem in which an output is required for the following positions of four cylinders A, B, C, and D:

1. A down, B, C, and D up.
2. A and B down, C and D up.
3. A, B, and C up, D down.
4. A, B, C, and D up.

From the method explained in the previous example, the switching equation is

$$f(\text{out}) = (A' + B + C + D)(A' + B' + C + D) \times (A + B + C + D')(A + B + C + D) \qquad (7)$$

and the negative becomes

$$[f(\text{out})]' = AB'C'D' + ABC'D' + A'B'C'D + A'B'C'D'$$

The last two terms yield

$$A'B'C'D + A'B'C'D' = A'B'C'(D + D') = A'B'C' \cdot 1 = A'B'C'$$

and the first two terms give

$$AB'C'D' + ABC'D' = AC'D'(B' + B) = AC'D' \cdot 1 = AC'D'$$

Thus,

$$[f(\text{out})]' = AC'D' + A'B'C' = C'(AD' + A'B')$$

and the negative gives finally

$$f(\text{out}) = [[f(\text{out})]']' = C + (A' + D)(A + B) \qquad (8)$$

This final expression is certainly much less complex than the initial expression. Further simplification might be obtained if particular combinations

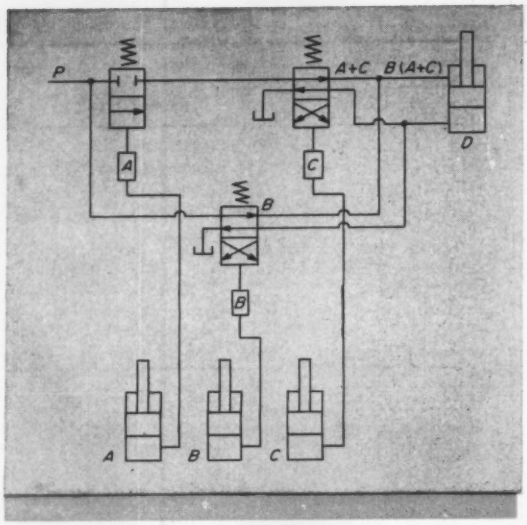


Fig. 5—Directional valves simplify circuit. Cylinder D still has motion of $f(D)=B(A+C)$

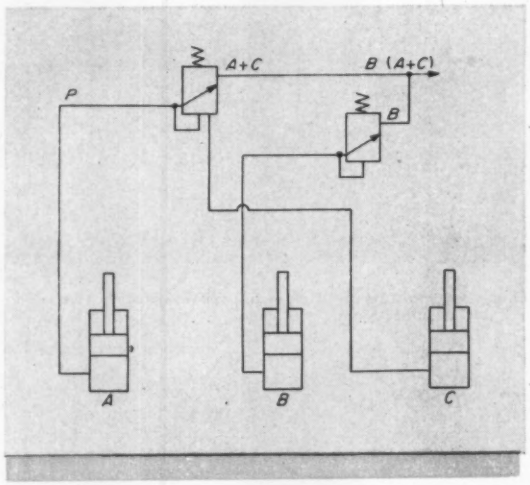


Fig. 6—Sequence valves used to control output. Function is $B(A+C)$, but output can be connected to any element

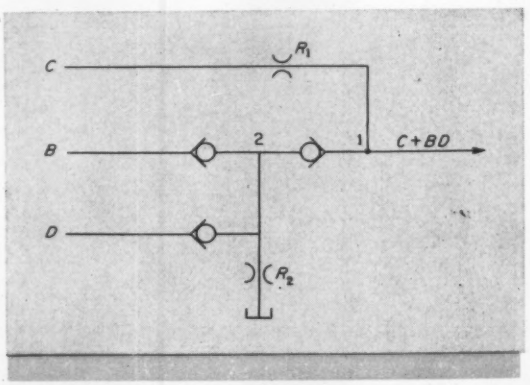


Fig. 7—Check-valve logic circuit with function $C+BD$

of A, B, C, and D never occurred or were of no consequence. Suppose that the combinations of A and D down, B and C up, plus B down, A, C, and D up never appear in the circuit under consideration. If, for the purpose of analysis, a circuit representing these combinations was placed in parallel with the circuit already developed, actual simplification results. In this case, the two combinations, $(A'+B+C+D')(A+B'+C+D)$, are added to Equation 7 and a simplified expression results.

The initial equation becomes

$$f(\text{out}) = (A' + B + C + D)(A' + B' + C + D) \times (A + B + C + D')(A + B + C + D) \times (A' + B + C + D')(A + B' + C + D) \quad (9)$$

and the expression is reduced by the following steps:

1. Take the negative of Equation 9.
2. Simplify the first and fourth terms.
3. Simplify the second and sixth terms.
4. Simplify the third and fifth terms.
5. Recombine these simplified results into an equation.
6. Simplify the first and third terms of this new equation.
7. Factor like terms from the expression.
8. Take the negative of this expression to obtain the final equation.

From this procedure, Equation 9 reduces to

$$f(\text{out}) = C + BD \quad (10)$$

Thus, an element has been eliminated by taking advantage of properties peculiar to a particular design.

Any of the standard components used in previous illustrations might be used to represent $C + BD$. This equation lends itself quite nicely, however, to the use of inexpensive check and needle valves. The circuit, Fig. 7, is best explained by considering input signals at points C, B, and D. If pressure appears at C alone, fluid flows through the check valve, R_1, between points 1 and 2, and then through R_2 to the tank. R_1 serves two purposes: To isolate C by limiting the amount of oil required from C, and to drop the pressure to a level which will not yield an output when B or D is not present. If pressure appears at B or D without appearing at C, oil is prevented from flowing to the output by the check valve between points 1 and 2. Valve R_2 isolates B and D, from the tank. When the pressure appears at C and B or D, the output is obtained by the pressure developed across R_2 which holds the check valve between points 1 and 2 closed and allows oil from C to actuate the output.

The second part of this article will discuss various commercial components and their switching equivalents, as well as memory, counting, and symmetric circuits.

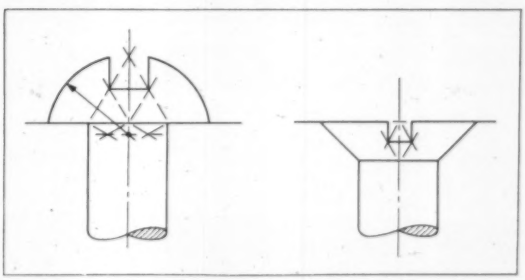
ACKNOWLEDGMENT

The author acknowledges with appreciation the co-operation of Prof. R. E. Anderson, Newark College of Engineering, and Dr. G. Reethof, Vickers Inc., in the preparation of this article.

Tips and Techniques

Drawing Standard Heads and Slots

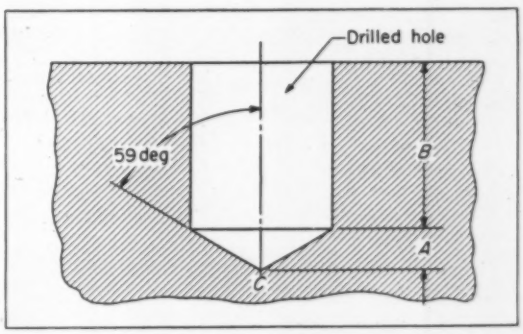
A quick and easy method of drawing standard heads for rivets or screws, and screw slots uses standard triangles. For snap-head rivets, all construction lines are at 30 or 60 deg to the center lines. Center of the arc which forms the head is determined by five construction lines below the surface of the metal, while height of the head is formed by two construction lines above. The arc is then drawn at this radius.



This construction is also used for a snap-headed screw. The slot is formed by drawing construction lines at 30 deg to the center line through the top and bottom of the head intersecting at the corners of the slot. For countersunk heads, the construction lines for the head are drawn at 45 deg to the center line.—W. H. SHEPPARD, *Renton, Wash.*

Calculating Drill Depth

To prevent overdrilling, or to figure cam rises for blind hole drilling operations, the exact depth of the conical point of a twist drill is required. This



depth, A, depends upon the drill diameter, D, and for standard, 59-deg drills can be determined from $A = 0.60086\ D/2$.—H. J. GERBER, *Stillwater, Okla.*

Handles for Electronic Equipment

Factors to consider when choosing handles, and examples of handle design and use, are presented here as a guide in providing the final touch that indicates thorough engineering on a piece of electronic equipment.

By FRANK WILLIAM WOOD JR.
Engineer, Systems Development Dept.
Vitro Laboratories
Silver Spring, Md.

Check List of Design Factors

Select a handle that . . .

1. Is available in preference to making a special design.
2. Provides hand and finger comfort.
3. Serves a second purpose as a lock, guard, support, etc.
4. Can be easily attached to the unit.
5. Is sturdy enough to withstand normal abuse.
6. Can support the weight of the equipment.

Be sure handle has . . .

7. A color and finish that blend with the unit.
8. A finish that will be permanent.
9. A style that adds to over-all appearance.
10. A rattleproof design for military applications.

Locate the handle . . .

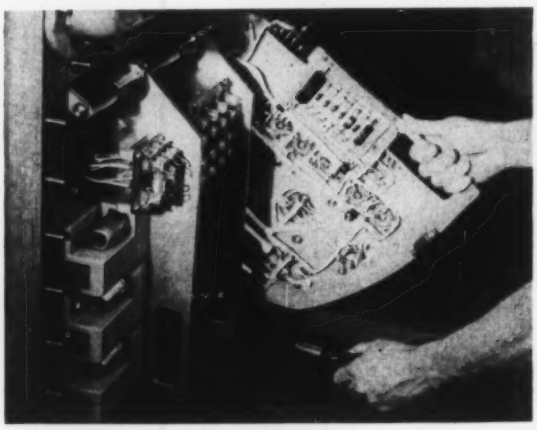
11. So it does not interfere with operation of controls.
12. Over center of gravity of portable units.

In package design, provide . . .

13. Storage space inside the unit for removable handles.
14. Handles for two men if required by unit size and weight.

1 **Combines maintenance features**

Comfortable handles, slides, and tilt-positioner reduce effort required to position this heavy unit for inspection.

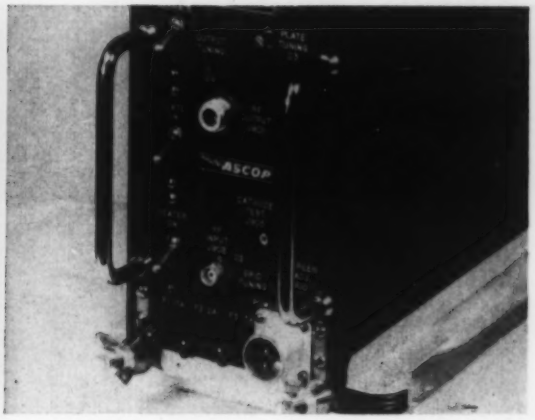


2 **Makes servicing easy**

Hand openings in swing-out plates permit easy access for maintenance work.

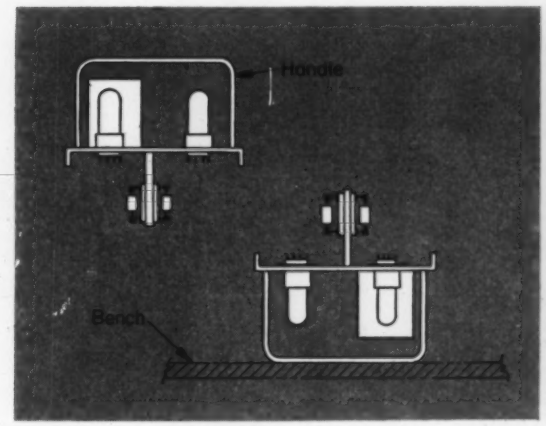
3 **Locks unit in rack**

Slotted "dog latch" in handle holds this chassis in place.



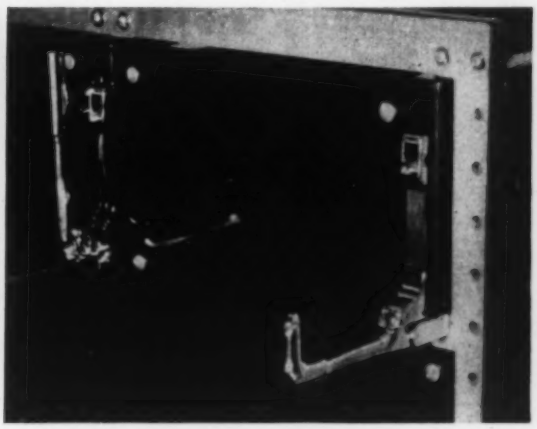
4 **Guards controls**

Carefully located handles reduce possibility of accidentally actuating the controls.



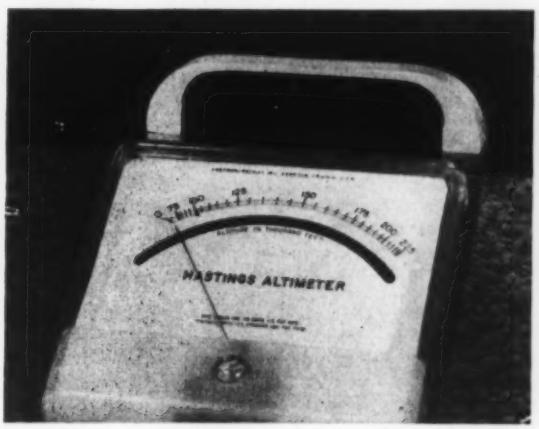
5 **Protects components**

Handles provide protective support for bench servicing.



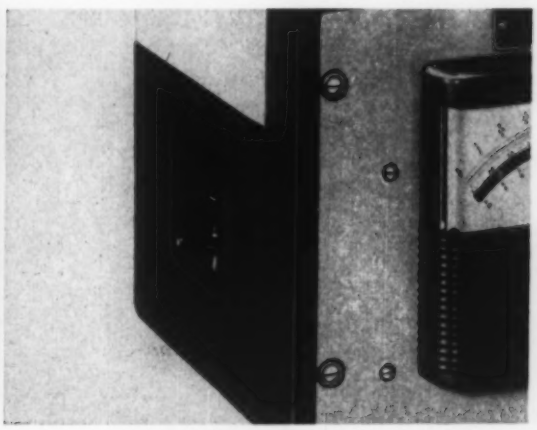
6 **Forces connections apart**

Engage-disengage lever, useful for multi-pin chassis connections, applies an engage force of 125 lb and a release force of 165 lb.



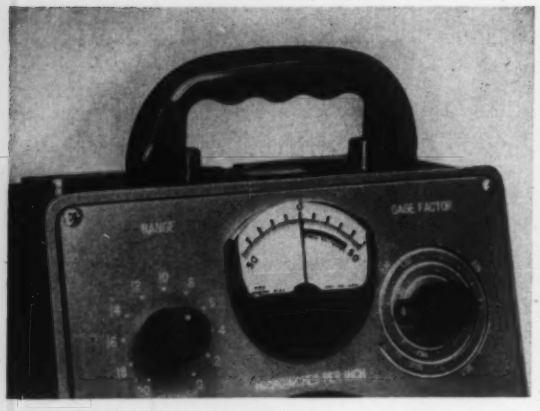
7 **Matches metallic finishes**

This cast handle is given a clear, anodized finish.



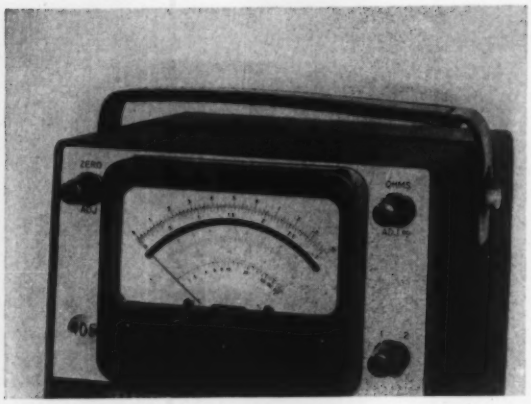
8 **Provides recessed lift**

Economy and space saving are obtained with this built-in finger lift.



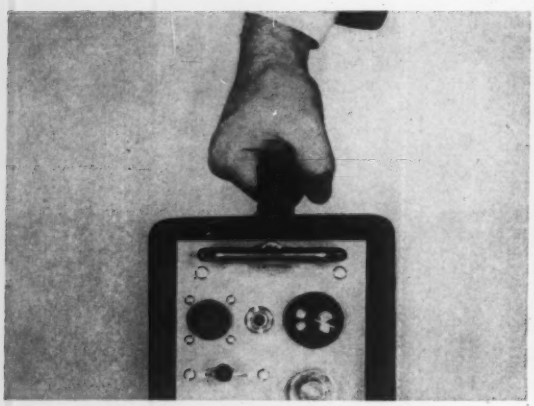
9 Prevents finger cramping

Finger contours in this custom handle prevent side pressure on fingers when lifting heavy instruments.



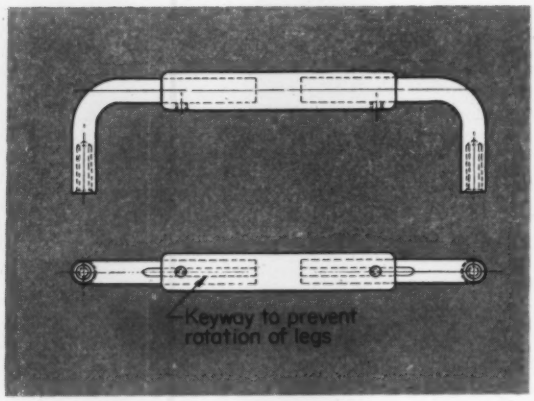
10 Eliminates rigid projection

Stitched leather or plastic straps make an efficient, flexible handle.



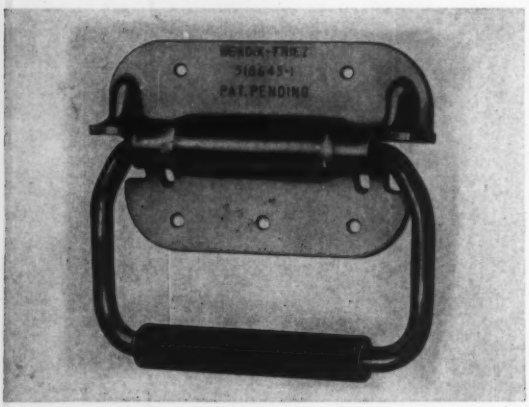
11 Permits choice of mounting

Whether rack-mounted or carried in its portable case, this instrument has suitable handles.



12 Adjusts to center distance

Mounting centers for this handle range between 4½ in. and 6⅝ in.



13 Silences rattle

With an internal spring to prevent rattle, this military handle supports 200 lb in its raised 90-degree position.

ACKNOWLEDGMENT

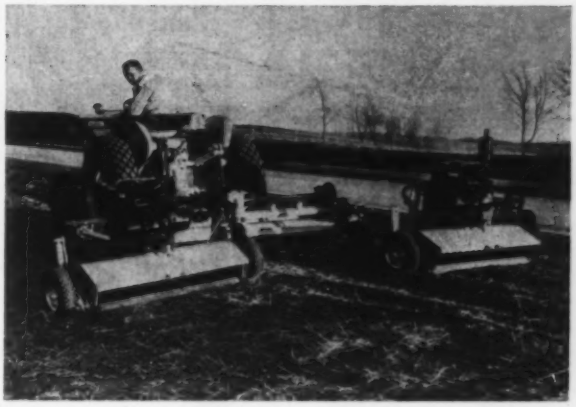
The author acknowledges with appreciation the cooperation of these companies in supplying illustrations:

Grant Pulley & Hardware Corp. (Fig. 1) ..... Flushing, N. J
Servonics Inc. (Fig. 3) ..... Alexandria, Va.
Applied Science Corp. of Princeton (Fig. 4) ..... Princeton, N. J.
Camloc Fastener Corp. (Fig. 6) ..... Paramus, N. J.
Hastings Instrument Co. Inc. (Fig. 7) ... Hampton, Va.
Weston Electrical Instrument Corp. (Fig. 8) ..... Newark, N. J.
Baldwin-Lima-Hamilton Corp. (Fig. 9) ..... Hamilton, Ohio
Allen B. Du Mont Laboratories Inc. (Fig. 10) ..... Clifton, N. J.
Sanborn Co. (Fig. 11) ..... Cambridge, Mass.
Cambridge Thermionic Corp. (Fig. 12) ..... Cambridge, Mass.
Friez Instrument Div., Bendix Aviation Corp. (Fig. 13) ..... Baltimore, Md.

Three Engines Power Three-Gang Mower

DRIVE POWER TRANSMISSION PROBLEMS are solved in the new three-gang Mott grass mowers by using three independent piston-engine power sources. The center mower is driven from the power take-off of an International 340 Utility tractor. The two trailing mowers are each powered by a 16.5-hp, two-cylinder Wisconsin engine. In narrow areas, or where the operation is difficult, the operator can detach either one or both of the trailing side units.

The trailing mowers are attached to each end of the center mower with ball-and-socket hitches. In the center of each mower section is also a ball-and-socket hitch which permits hooking them in tandem for transport.

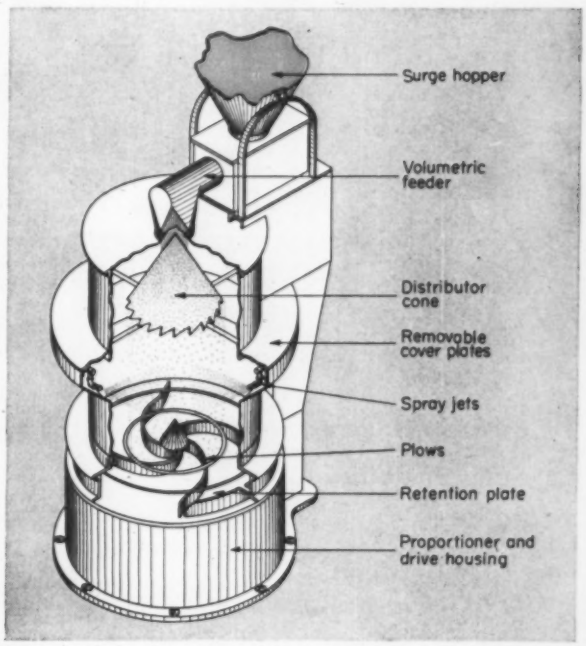


Cone Spreads Falling Stream Of Material into Thin Layer

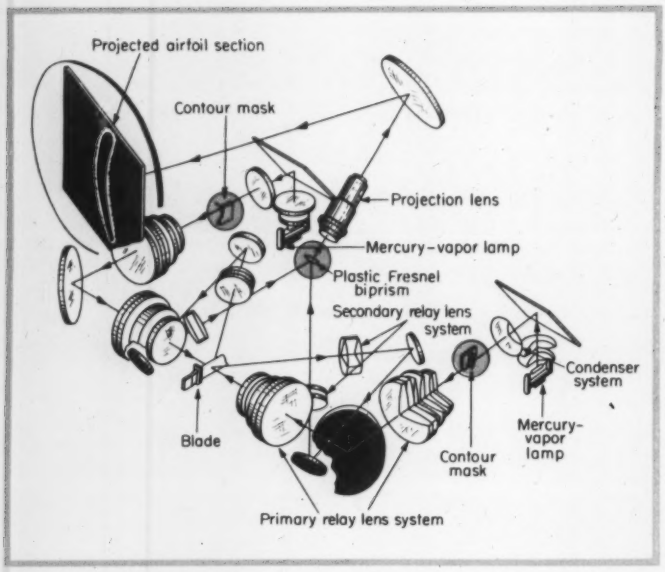
CURTAIN OF MATERIAL falling off a cone-shaped element simplifies mixing of liquids or fine solids in a continuous-flow blender. A feeder under the surge hopper of the blender feeds a solid stream of dry materials onto the apex of the cone. This stream is spread out as it slides down the cone and falls off in a thin curtain into the mixer below.

At the base of the cone, spray headers disperse liquid into the falling particles in any proportions required. Liquid can be sprayed from both inside and outside the curtain as it falls from the cone.

These design features are incorporated in a new blending machine developed by Johnson-March Corp., Philadelphia, Pa.

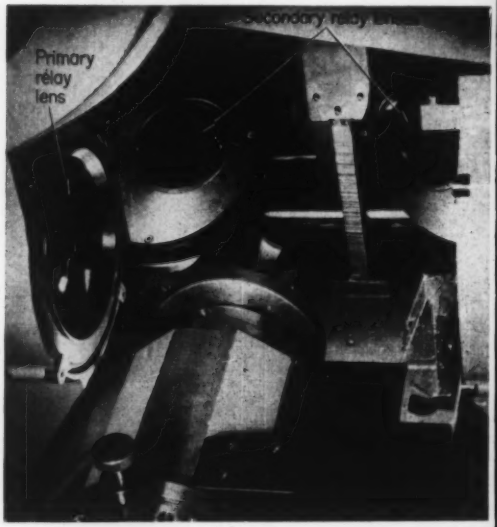


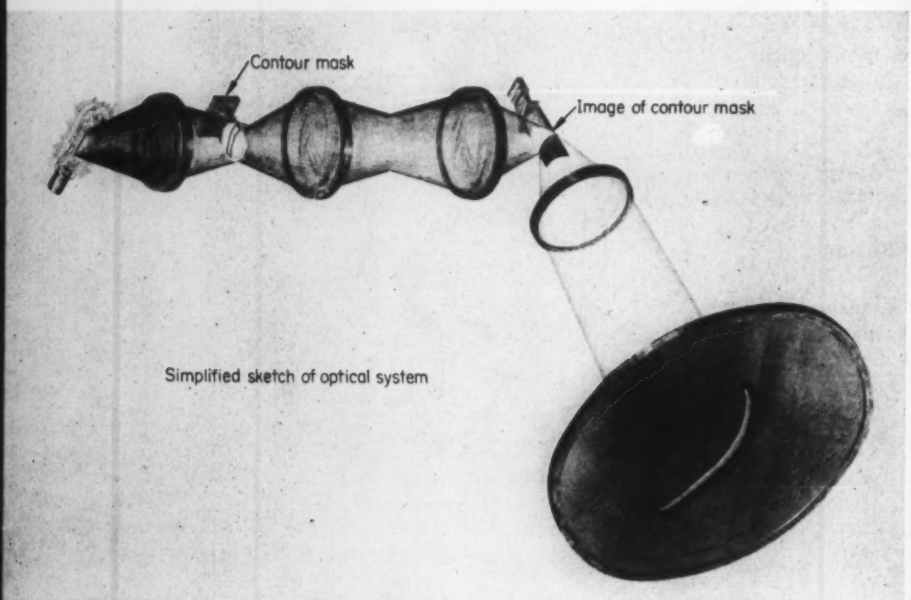
Plastic Biprism Combines



TWO IDENTICAL OPTICAL SYSTEMS project a single magnified profile of complex objects by matching half profiles exactly. Two 1000-watt, mercury-vapor lamps illuminate at high intensity both sides of the object being projected. These lamps, which are 1 in. long and 1/16-in. wide (capillary), have a brightness of 29,500 c/sq cm.

BRIGHT LINE OF LIGHT outlining the blade section is picked up by two secondary relay lens systems placed at angles of 35 deg to the blade. Viewing at these angles prevents interference of the light beam by blade shrouding or high twist, and permits inspection of long blades.





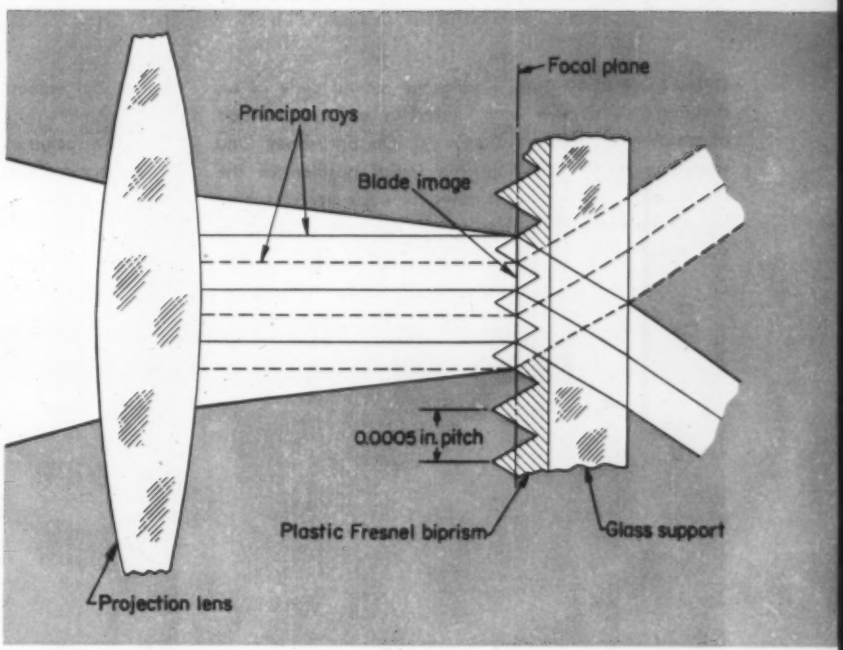
Simplified sketch of optical system

SPECIAL CONTOUR MASK and a special set of relay lenses in each half of the optical system project a sharply defined line of light on the object, such as an airfoil. The primary relay lens system focuses curved types of objects (the contour mask) on curved surfaces (the blade). The contour mask, which has form in the focal direction, can be brought into sharp focus across the full width of the airfoil blade section. The masks serve, in effect, as secondary light sources of the proper shape to fit the blade.

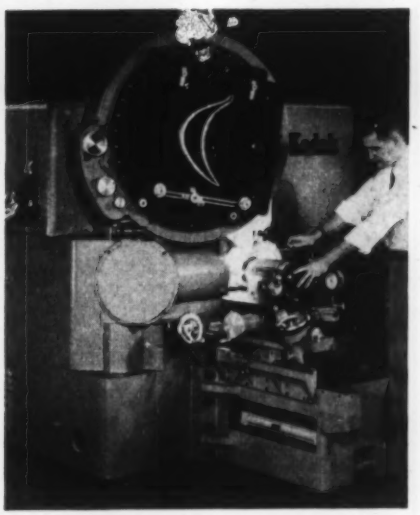
Two Image Halves into One

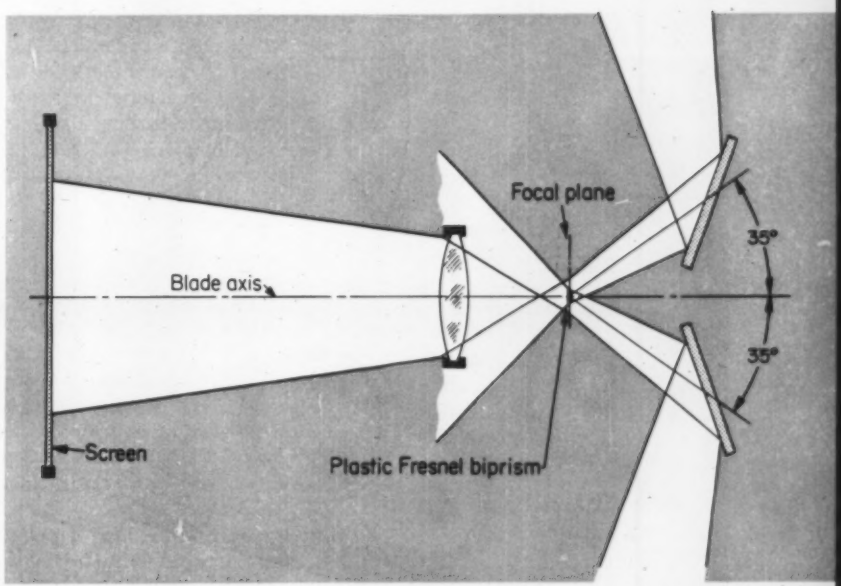
FRESNEL BIPRISM redirects images of each side of the blade so they enter a single projection lens correctly and pass on to the viewing screen. The beams of light from the two halves strike the biprism at an angle of 35 deg, or 70 deg between beams.

In design, the Fresnel biprism consists of a series of fine plastic prisms mounted on a glass support plate. The "mold" for the plastic biprism was made by cutting a spiral prism groove on a bronze cylinder using a lathe and a diamond tool. The plastic replica of the grooves was obtained by a solvent transfer process.



SECTION-PROFILE PROJECTOR built by Eastman Kodak Apparatus and Optical Div. permits viewing of an entire cross section at any point along the axis of a compressor blade, vane, turbine bucket, or half of a forging die. Dimensions of parts, such as blades, can be measured to 0.0001 in. and twist to 1 minute of arc. As reported by designer Allen R. Fultz, the instrument can project entire sections of actual turbine blades in lengths up to 16 in., with 2¼-in. chords and 45-deg twist. Section profiles appear on 30-in. diameter screen as a dark image sharply outlined by a bright band of light.

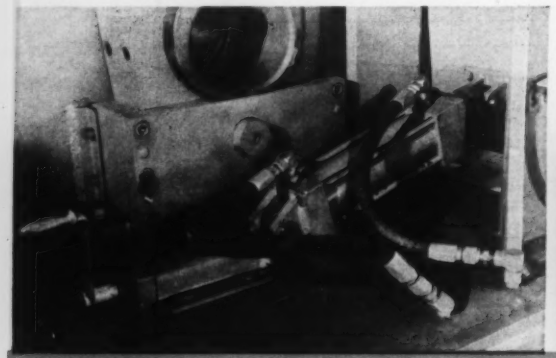


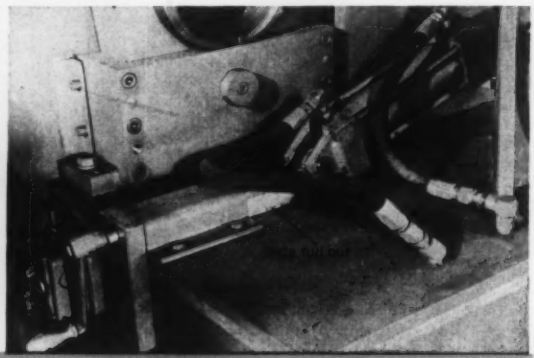


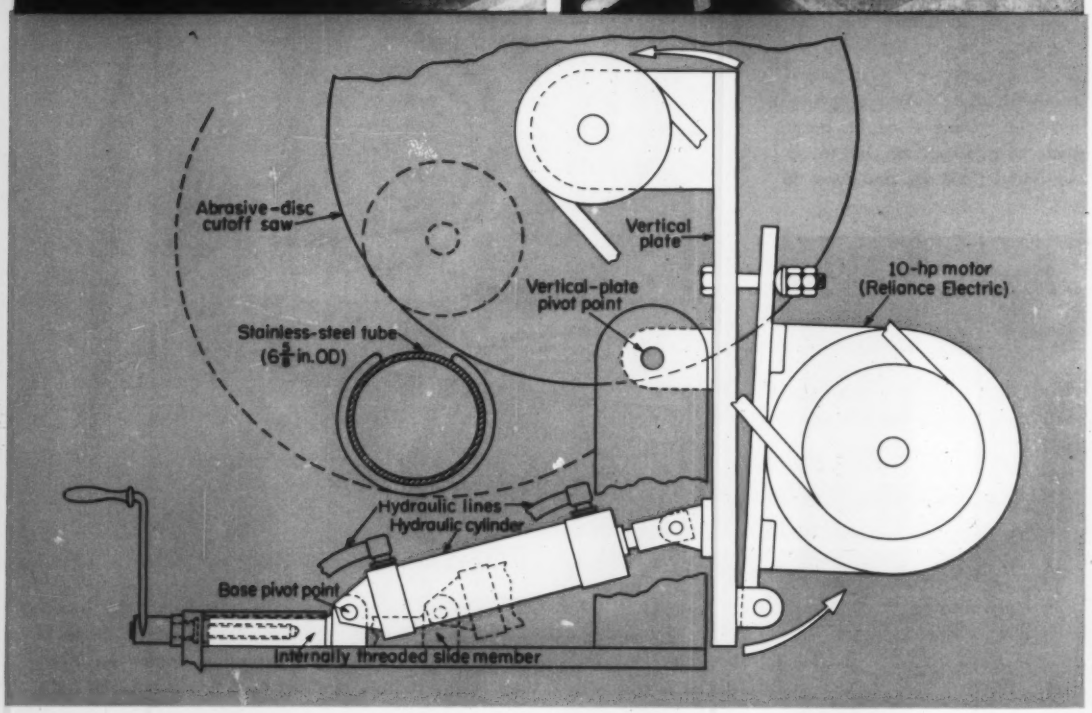
Hydraulic-Mechanical Linkage Has Adjustable-Position Pivots

OPERATION DEAD TIME during the cutting cycle of an automatic cutoff saw is minimized by a simple method of positioning the saw assembly. On an Abbey Etna travelling-cutoff tube mill, the initial position of the abrasive-disc cutoff saw is reset for each size of tubing run through the mill. The saw is brought as close to the tube being cut as possible. Saw position is adjusted by manually cranking an internally threaded slide member which moves the base pivot point of the hydraulic actuating cylinder.

The complete cutting cycle for a $6\frac{5}{8}$ OD stainless-steel tube with a $\frac{1}{4}$-in. wall thickness takes about 11 sec. The cylinder has a maximum stroke of 7 in. and operates on about 160-lb pressure.







When to specify

MICROHONING

for precision surfaces and close tolerances on high-production parts

By DON S. CONNOR
President
Micromatic Hone Corp.
Detroit, Mich.

MICROHONING is of particular interest to the design engineer because of its ability to generate, and consistently duplicate, the functional characteristics vital to surfaces that must carry loads, retain lubricant, or form seals.

Although Microhoning is applicable primarily to ID and OD cylindrical surfaces, the same principles of controlled abrading are used on flat and tapered surfaces, internal splined surfaces, bearing raceways, and spherical surfaces.

Advantages: Microhoning generates geometric tolerances to 0.00005 in., surface finishes to any specified microinch value, and diametral tolerances within 0.0002 to 0.0003 in. Stock-removal rates of 0.018 ipm may be obtained in bores whose lengths do not exceed their diameters by more than a three-to-one ratio. Stock-removal rate in longer bores is inversely proportional to bore length.

Because abrasive grain is used as the cutting medium, Microhoning is often classified with grinding or lapping. The relation is justified only in that Microhoning combines the productive capacities and processing economies of grinding with the precision-generating abilities of lapping. With Microhoning, there is no interruption of the process cycle to dress the abrasive and no dulling of abrasive grit to cause variations in finish.

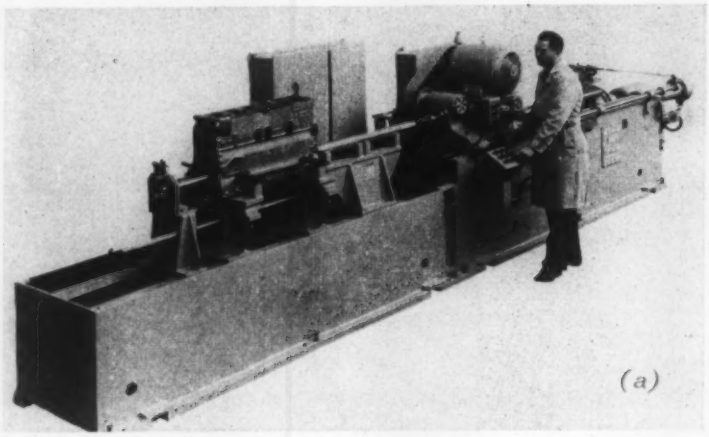
Flatness of production parts can be held to with-

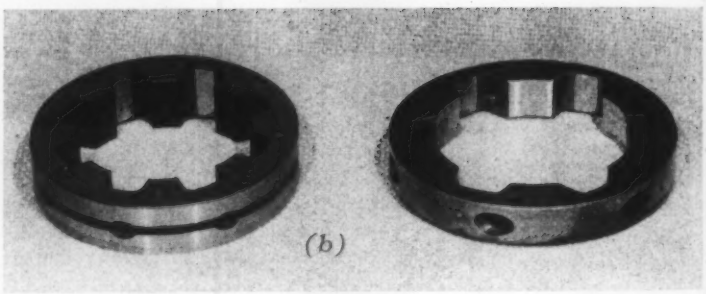
Applications of Microhoning

Cylindrical Workpieces: Bores from ⅛ to 42 in. in diameter have been Microhoned successfully. Length of the workpiece can vary from a fraction of an inch to more than 50 ft. Several hundred small parts can be stacked to form a continuous cylinder and Microhoned in one setup.

Bores interrupted by ports, keyways, undercuts, and annular grooves, and tandem bores of varying diameters, can be Microhoned to perfect alignment. Accuracy generated by Microhoning an engine block, Fig. *a*, simplifies assembly of bearings and crankshaft. Consistent surface finishes and close tolerances with a minimum of overcutting at the edges of interruption are produced.

Microhoning OD surfaces on piston rods and guide bars, for example, results in true cylindrical surfaces free from geometric errors. The resulting cross-hatch pattern is ideal for oil retention, which minimizes wear on mating parts.


(a)


(b)

in a few light bands by Microhoning. Materials range from the hardest metals to light alloys. Two opposing surfaces of a single part may be Microhoned simultaneously. Large or small production runs are handled with equal facility.

Surface Characteristics: In conventional Microhoning, either the tool or workpiece is "floated" so that self-alignment takes place. Pressure applied to the abrasive during feed is controlled and directed so that equal abrading action takes place on the entire surface of the bore while the tool rotates and reciprocates. Abrasive sticks are forced radially against the bore surface by wedging action from within the tool. If the bore is tapered or out-of-round, high spots are abraded first until the surface is round and the axis straight.

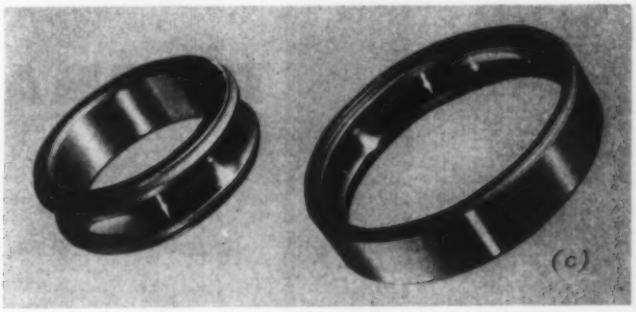
Although stock removal is substantial, there is never sufficient heat concentrated at any single point to damage the surface or subsurface structure. The surface is cut clean without smear or burned metal. There is no impregnation by the abrasive no matter how soft the material.

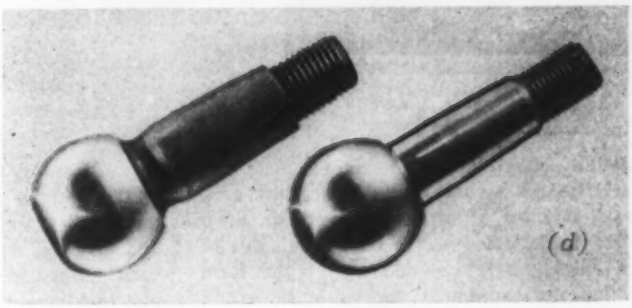
The resulting cross-hatch surface pattern pro-

Gears, Cams, Splines: An economical method of processing gears is to specify Microhoning for bores of gear blanks. Teeth are then cut concentric with the accurate bore. After heat treatment, the bore is Microhoned to final specifications. Because the tool and workpiece align themselves, location of the bore, in relation to the teeth, is not changed.

Pinion gears which require parallel faces and bores perpendicular to the faces are Microhoned in two operations. The first, performed on a double-surface machine, controls thickness, generates parallelism, and produces a uniform finish. The second produces the perpendicular bore on a vertical machine. The part "floats" in the fixture until the tool expands and centers the gear with the machine spindle. When the part is located, it is clamped against a plate whose surface is perpendicular to the spindle. The bore is then Microhoned, its axis generated square to the side faces.

Internal splines, Fig. *b*, and cams requiring a true radius and functional surfaces are easily Microhoned. Since the tool cannot be rotated, an oscillating motion is combined with the usual reciprocating motion to obtain cutting action.





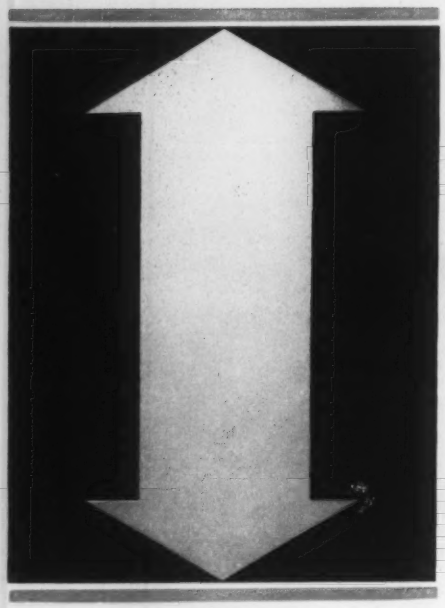
Bearings and Spherical Parts: Microhoning generates accurate geometry and controls functional finishes in ball-bearing raceways, Fig. c. Accuracy is attained without weakening or damaging bearing material. The abrasive stick is oscillated across the raceway during part rotation. Sphericity of balls and similar parts, Fig. *d*, is held within 0.0003 in., and any required surface finish is obtained repeatedly. Here, the ball studs are Microhoned concentric with the tapered shank. The axis of the stud is held at an angle and rotated. Abrasive encircles half the sphere and abrades equally the entire surface.

vides minute diamond-shaped plateaus which serve to distribute loads over many bearing points. Each plateau is bounded by intersecting valleys which act as lubricant reservoirs.

Microhoning produces a diametrally and geometrically accurate surface free from amorphous metal. Such a surface will not scuff or flake off under load.

Cost: In some applications involving long tubing, extremely hard materials, interrupted surfaces, or consistency close tolerances, Microhoning actually costs less than other machining methods. Many hydraulic cylinders, for example, are manufactured by Microhoning the bore of stock tubing to specified size and cutting the tubing to required lengths. As much as 0.125 in. of stock may be removed, and no other machining is required.

Generally, for the most economical processing, the bulk of excess stock should be removed by rough machining. Microhoning then corrects inaccuracies in the surface and generates the required finish. A rough surface left by operations preceding Microhoning reduces time required for final finishing.



THERMAL STRESSES

By S. S. MANSON
Chief, Materials and
Structures Research Div.,
Lewis Research Laboratory, NASA
Cleveland, Ohio

A LARGE class of problems in elasticity has been treated by techniques which are generally denoted as variational methods. Such methods are based on concepts of the calculus of variations. The objective is to determine which form of a function $f(x)$ minimizes the value of certain definite integrals containing the function and its derivatives.

The term variational characterizes this method because consideration is given to a variation in $f(x)$, $g(x)$, which passes through the same end points on a line and differs from $f(x)$ by a small quantity.

Variational methods are applicable to the solution of elasticity problems because the integrals which represent stored energy in a body undergoing elastic deformation have certain properties. Each element of the body stores strain energy when a force moves through a displacement. Energy stored in the body is expressed as a single, double, or triple integral, depending on whether the body is one, two, or three dimensional. External forces also do work during deformation. In fact, by the principle of conservation of energy, the work expended by external forces is equal to the energy stored by elastic deformation. Various combinations of the energies involved can be formed, depending on which variables are specified and which remain unknown, and any of several minimum energy principles can be applied. For thermal-stress purposes, only the principle of minimum complementary energy has found extended application.[8, 9]

Complementary Energy

When an element of volume is elongated by stress action, energy is stored. This energy per unit volume is $\int \sigma d\varepsilon$ and is the area bounded by the stress curve and the strain axis, Fig. 55*a*. The area bounded by the stress-strain curve and the stress axis is $\int \varepsilon d\sigma$ and also has the units of energy. This energy has been termed complementary energy, and the sum of strain energy and complementary energy always equals the product of the final stress and strain states.

For ordinary elasticity problems, strain is proportional to stress, and no distinction is made between strain energy and complementary energy since the two are equal. The major use for the concept is in nonlinear elasticity problems where the two energy quantities are not equal, Fig. 55*b*. There is also a significant difference between the two energies in thermal-stress problems, even if the stress-strain curve is linear, since the curve is displaced to the right by an amount αT, Fig. 55c. Thus, for uniaxial stress, strain energy is $\sigma\varepsilon/2$, and the complementary energy is $(\sigma\varepsilon/2) + \sigma\alpha T$.

A flat plate with biaxial stresses can be used to illustrate the formulation of complementary energy expressions. From the complementary energy definition and the stress-strain relationships,

$$\varepsilon_x = \frac{\sigma_x - \mu\sigma_y}{E} + \alpha T \qquad \varepsilon_y = \frac{\sigma_x - \mu\sigma_y}{E} + \alpha T$$

$$\gamma_{xy} = \frac{2(1+\mu)}{E}\tau_{xy}$$

and the complementary energy per unit volume is

$$\int (\varepsilon_x\, d\,\sigma_x + \varepsilon_y\, d\,\sigma_y + \tau_{xy}\, d\,\gamma_{xy})$$

$$= \frac{1}{2E}\left[\sigma_x^2 + \sigma_y^2 - 2\mu\sigma_x\sigma_y + 2E\alpha T(\sigma_x + \sigma_y) + 2(1+\mu)\tau_{xy}^2\right] \qquad (40)$$

To obtain the expression for complementary energy

[8, 9] References are tabulated at end of article.

IN DESIGN

Part 8—Elastic Stresses by Energy Methods

- **Complementary Energy**
- **Single Product Method**
- **Self-Equilibrating Polynomials**
- **Station Functions**

in an element $dydx$, Equation 40 is multiplied by $dydx$. Also, when stresses vary throughout the body, the total complementary energy is the integral of the elemental energy. Thus,

$$U = CE = \frac{1}{2E}\int_A \Big[\, \sigma_x^2 + \sigma_y^2 - 2\mu\sigma_x\sigma_y + 2E\alpha T(\sigma_x + \sigma_y) + 2(1+\mu)\tau_{xy}^2 \,\Big]\, dydx \qquad (41)$$

In most two-dimensional problems, which involve specified boundary forces, stress distribution is independent of Poisson's ratio. Thus, arbitrary values of μ can be selected for convenience to simplify the expression. If $\mu = -1$ is selected, the τ_{xy} term is eliminated and Equation 41 becomes

$$U = \frac{1}{2E}\int_A [(\sigma_x + \sigma_y)^2 + 2E\alpha T(\sigma_x + \sigma_y)]\, dydx \qquad (42)$$

In a similar manner, selection of $\mu = 0$ eliminates the $\sigma_x\sigma_y$ term.

Principle of Minimum Complementary Energy: To solve an elasticity problem, the equations of equilibrium and compatibility must be solved, and all specified boundary conditions must be taken into account. In one approach, all sets of functions which satisfy the equilibrium equations are chosen, and the correct set is found by ascertaining the set which also satisfies the compatibility equations.

However, the second step in the preceding analysis can be eliminated and the correct set of stresses can be found by determining the set which makes the complementary energy of the body a minimum. Variational methods show that the condition of minimum complementary energy is exactly equivalent to the condition of compatibility. Theoretically, the complementary energy of some of the external forces must be added to the complementary energy of the internal stress system before the function is minimized. However, only the surface forces not specified are considered. If the displacements

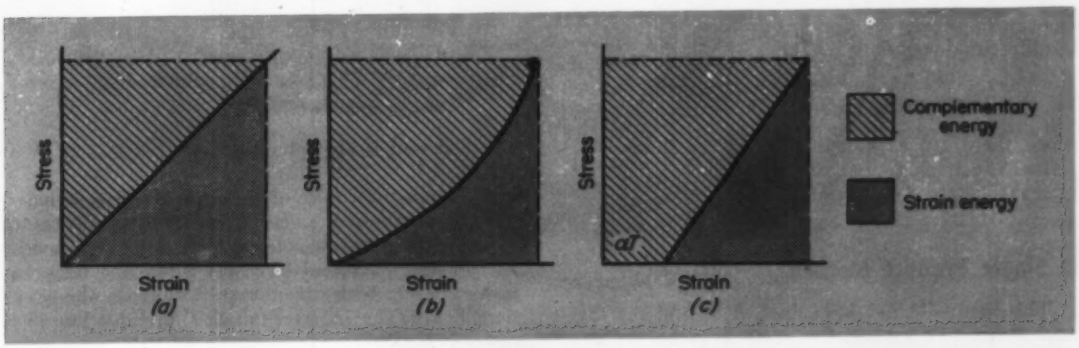


Fig. 55—Complementary and strain energies. Areas enclosed by stress-strain curves for, *a*, linear elasticity with only mechanical strain present, *b*, nonlinear elasticity, and *c*, linear elasticity for thermal stress with thermal expansion and mechanical strain present

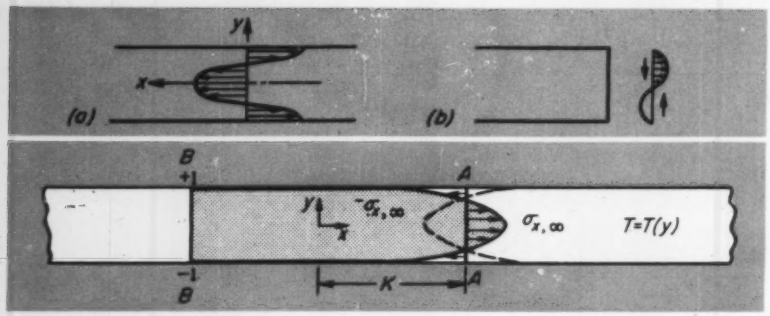


Fig. 56—Self-equilibrating stress systems: *a*, normal stress, and *b*, shear stress

Fig. 57—Self-equilibrating system in finite flat plate. Plate dimensions are 2 by 2*K*, in which 2*K* dimension is imagined extended to infinity. Axial stress is determined for temperature variation in *y* dimension only

in a region of the body are specified, then the reactions at these regions are considered when the accountable terms are added to the complementary energy. Fortunately, surface forces are usually the forces specified. Therefore, they can be neglected. The displacements specified are usually zero, and the complementary work of the unknown reactions is also zero.

APPLICATION TO THERMAL STRESS PROBLEMS: The complementary-energy principle is advantageous because the set of functions selected automatically satisfies the equilibrium equations. Such a general set of functions is available in the Airy stress function. If the Airy relationships, Equation 26,[6] are substituted in Equation 42, an expression is obtained in terms of only ϕ. Thus, minimizing the complementary energy by standard variational procedures results in an equation for ϕ.

Unfortunately, it is not possible to arrive at any new relation if ϕ is retained as an unknown function of x and y. When the variational procedure is carried through, a biharmonic equation results. This equation simply indicates that the complementary-energy principle and the compatibility equations are equivalent for determining true stress distribution.

The merit of the energy method is that approximate, rather than exact, solutions are obtained by methods similar to other applications of structural analysis. A form of the stress function ϕ is assumed, $\phi = P_1(y)\,\phi_1(x) + P_2(y)\,\phi_2(x) + \ldots + P_n(y)\,\phi_n(x)$, in which y functions are known and x functions unknown. When ϕ is substituted in the complementary energy equation, required integrations with respect to y are performed, and a series of differential equations result.

$$\frac{\partial F}{\partial \phi_n} + \frac{\partial^2}{\partial x^2}\left(\frac{\partial F}{\partial \phi_n''}\right) = 0$$

Since there are as many equations as there are ϕ terms, functions ϕ_1, ϕ_2, etc., for values of P_1, P_2, etc., are obtained by simultaneous solution.

Single Product Method

This method[10] has been applied to find the thermal stresses in a long, flat plate bounded by $x = \pm a$, $y = \pm b = \pm 1$ and with a temperature distribution of

$$T = T_0 + X(x)Y(y)$$

As a first approximation, the stress function was assumed to be given by a single term which involved the product of two functions, $\phi = f(x)g(y)$. One of these functions was in terms of x only, and the other in terms of y only. Hence, from Equation 26, $x = g''f$, $y = gF''$, and $\tau_{xy} = g'g'$, where the primes indicate differentiation of the function with respect to its assigned variable.

In the problem treated analytically and experimentally by Heldenfels and Roberts, the temperature varied only in the short y-dimension, but was constant in the long x-dimension. As discussed in the beam theory solution,[7] the stress distribution in such a beam is readily determined by Duhamel's analogy. These stresses are valid except near the ends of the beam where the normal and shear stresses reduce to zero. Hence, it is only near the ends that a rigorous solution by stress functions is required. However, since the stresses are known in the major portion of the plate, a consistent form of the stress function is used in this portion. Thus, from Equation 35,[7]

$$g'' = \sigma_{x,\infty} = -\alpha E\left[T + \frac{1}{2}\int_{-1}^{+1} T\,dy + \frac{3y}{2}\int_{-1}^{+1} T y\,dy\right] \qquad (43)$$

where $T = T(y)$ is a function of y only. The function $f(x)$ becomes unity over most of the plate and shows variation only at the ends. Equation 43 is integrated twice to obtain an expression for g in terms of two arbitrary constants which are determined from boundary conditions along the long edges. Thus,

$$g = \int_0^y \int_0^y \sigma_{x,\infty}\,dy\,dy + Ay + B$$

where A and B are determined so that $g = g' = 0$ at $y = \pm 1$.

Although the choice of the form for $g(y)$ is based on consideration of a long beam with temperature variation in only the narrow y-direction, the method can be generalized for cases where the temperature varies in both directions according to the equation $T = T_0 + X(x)\,Y(y)$ if T in Equation 43 is replaced by $Y(y)$.

The method of Heldenfels and Roberts has been applied to determine the stresses in a flat plate which had transverse temperature distributions of various

types.[11] The results will later be shown and compared with computations by other methods. The method was also extended to plates with a chordwise thickness variation and chordwise temperature variation. These conditions occur in aircraft wings and turbine buckets. The principles of procedure are similar to those for flat plate, except that the thickness is accounted for in the expression for complementary energy.[11]

Self-Equilibrating Polynomials

One of the major limitations to the method of Heldenfels and Roberts is the fact that the solution is a single product of functions of x and y. If more terms are included, a question arises as to the form of $g(y)$. One approach which involves the use of orthonormal self-equilibrating polynomials has been devised. This approach has been applied to the solution of thermal stresses in rectangular strips with various temperature distributions. The method will first, however, be considered in connection with the end loading of a beam, and later to applicable thermal stress problems.

Self-Equilibrating Stress System: Any arbitrary distribution of normal load on the end of a beam can be replaced by a combination of: 1. Resultant force, 2. Resultant moment. 3. Self-equilibrating stress system which has a zero net force and moment, but with a shape that causes the sum of the entire system to have a specified load distribution. Components 1 and 2 above are treated by elementary beam theory. Hence, the only component of concern is 3 which has an effect only near the end of the beam. Negligible effect is present in sections remote from the end. In this discussion, only the self-equilibrating portion is considered. One possible distribution for a self-equilibrating end-loading system of the normal and shear types is shown in Fig. 56. For shear, the resultant only is zero. The plate is assumed thin in the direction normal to the plane of the paper. From the condition of self-equilibration,

$$\text{Force} = \int_{-1}^{+1} \sigma_x dy = 0 \qquad \text{Moment} = \int_{-1}^{+1} y\sigma_x dy = 0$$

The polynomial stress-function which yields the end traction σ_x, upon suitable double differentiation, is called a self-equilibrating polynomial. Thus, if f is such a polynomial in y, $\sigma_x = f''$. The conditions for a self-equilibrating polynomial are

$$\int_{-1}^{+1} f'' dy = \int_{-1}^{+1} y f'' dy = 0$$

Because of the properties of orthogonality and normality, any self-equilibrating function is expandable in terms of tabulated self-equilibrating polynomials.[13] If ϕ_k is any polynomial, ϕ_k can be expressed in terms of $f_2, f_3, \ldots, f_k$, where the subscripts refer to the degree of the polynomial:

$$\phi_k = C_2 f_2 + C_3 f_3 + C_4 f_4 + \ldots . C_k f_k \qquad (44)$$

As long as ϕ_k is a known function, the coefficients $C_2, \ldots, C_k$ can be numerically determined, and the expression ϕ_k can be expressed in terms of self-equilibrating polynomials.

The functions f are functions of y only, and to introduce the variable x, so the stress function can be used to determine stresses at locations other than the immediate end, each of the terms, Equation 44, is multiplied by a function of x. Thus ϕ becomes $\phi = C_2 f_2 g_2 + C_3 f_3 g_3 + C_4 f_4 g_4 + \ldots + C_k f_k g_k$. The functions g are determined by substitution of ϕ into the complementary energy equation, and minimizing the energy. Again, because of the orthogonality of the polynomials, equations for g_k in terms of the known value of f_k is written.[13]

$$g_k'''' - 2g_k'' \int_{-1}^{+1} (f_k')dy + g_k \int_{-1}^{+1} (f_k'')dy = 0$$

Thermal-Stress Applications: As previously indicated, the method is applicable to cases which can be broken down into an equivalent end-problem of a beam or plate. The finite rectangular plate, with uniform temperature in the x-direction and with a temperature variation in the y-direction only, yields to such conversion. The plate is first imagined extended to infinity in both horizontal directions, Fig. 57. Then, by the beam theory treatment, the stress is determined in any cross-section as a self-equilibrating system, since the resultant must be in equilibrium with the external loading which is zero.

If the plate is imagined cut across section *AA*, and an equal and opposite stress-system applied, the stress system on the face will be zero everywhere, as required. Hence, the stresses produced by the end tractions are first determined by the method of self-equilibrating polynomials, and the results are added to the uniform stress system throughout the plate. The method is limited, however, to plates in which the length is several times the height. In such cases, the action of the self-equilibrating stress system on section *AA* has a vanishing effect on section *BB*. The converse is also true.

When the plate is narrow, the interaction must be considered, and the concept of the method is still valid, but the details are different.

Other thermal-stress problems, Fig. 58, have been treated by this method.[14, 15] Any temperature distribution in a long strip can be generated by combinations of the elemental temperature distributions. The technique for converting these problems into end-loading problems is, however, more indirect. Horvay[15] first treats these problems by means of Fourier integrals, and then evaluates the self-equilibrating shear in place of temperature discontinuity. This shear loading is then treated, in an analogous manner to the normal-loading problem, using orthonormal self-equilibrating polynomials.

Another extension of the method, which treats plates of variable thickness and with temperature which varies in only one direction, has been described by Singer.[11] Here, again, the method involves considerable numerical calculation.

Station Functions

Both variational methods thus far described are

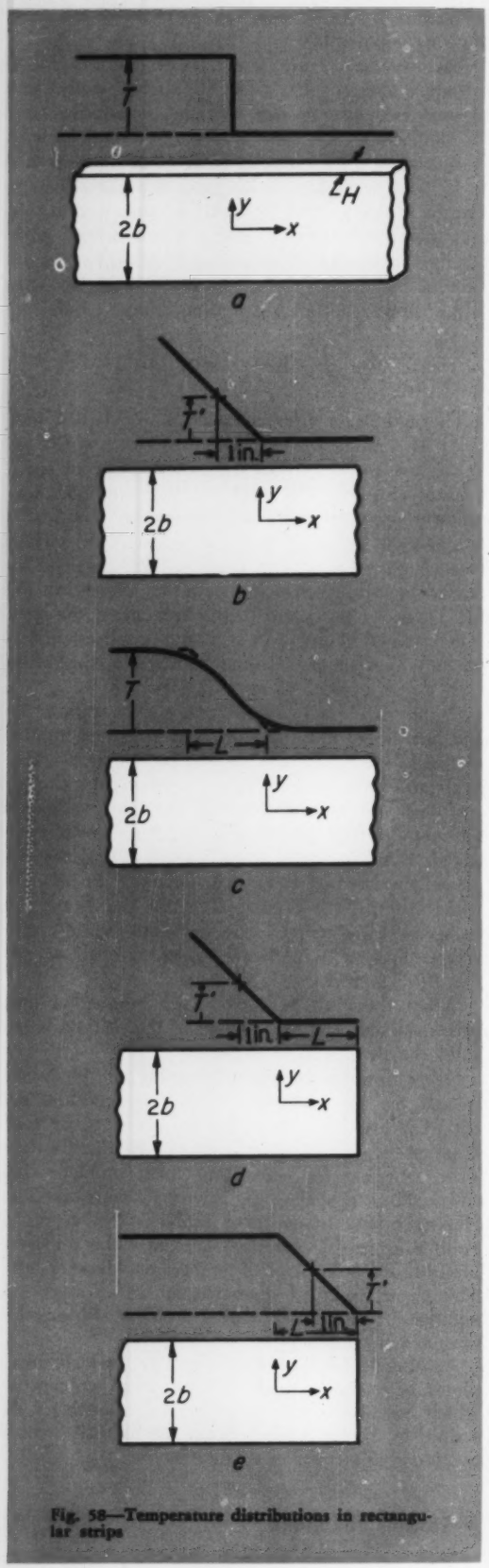


Fig. 58—Temperature distributions in rectangular strips

subject to severe limitations. The method of Heldenfels and Roberts is inherently limited by the choice of a stress function which consists of a single product of functions of x and y. Further limitations are imposed because of the temperature variation. The self-equilibrating polynomial method is limited to cases in which the temperature varies in one direction only and the width is several times the height.

In practice cases are encountered where the limitations of both methods are unduly restrictive. Hence, it is desirable to introduce a method that has neither of these restrictions. The only limitation of the method is that it involves considerable computation, which depends upon the degree of accuracy required. Since high-speed computing machinery is readily available in most organizations concerned with the problem, the added generality of the method overcomes its limitation.

A complete description of the basis for the method will be given in a later section when station functions and collocations are more generally introduced. It is desirable to indicate only that the method makes use of a stress function in the form of

$$\phi = P_1(y)\phi_1(x) + P_2(y)\phi_2(x) + P_3(y)\phi_3(x) \ldots \qquad (45)$$

where the y-components are polynomials in y and can be written by inspection. Equation 45 for ϕ is substituted into the equation for complementary energy, and then the minimizing equations are applied. The minimizing equations always provide as many equations as there are ϕ terms. These equations can be determined by classical means in terms of exponentials. However, a collocations procedure, which reduces the labor, can also be used to solve these equations. In this procedure the differential equations are satisfied only at a selected number of x values, rather than for all values of x. This method is also discussed in a later section.

The next article in this series explains the use of the reciprocal theorem and finite differences for solution of thermally induced elastic stresses.

References

This article is the eighth in a series by S. S. Manson on thermal stresses in design. Previous articles and issues of Machine Design in which they appeared are:

1. "Appraisal of Brittle Materials" ..... June 12, 1958
2. "Quantitative Techniques for Brittle Materials" .... June 26, 1958
3. "Basic Concepts of Fatigue in Ductile Materials" . August 7, 1958
4. "Causes of Fatigue in Ductile Materials" ..... August 21, 1958
5. "Interpretation of Fatigue Data for Ductile Materials" ..... September 4, 1958
6. "Elastic Stress Analysis" ..... January 22, 1959
7. "Exact and Approximate Solutions" ..... February 5, 1959

Other references mentioned in this article are:

8. I. N. Sokolnikoff—*Mathematical Theory of Elasticity*, McGraw-Hill Book Co., New York, N. Y., second edition, 1956, pp. 377-475.
9. K. P. Den Hartog—*Advanced Strength of Materials*, McGraw-Hill Book Co., New York, N. Y., first edition, 1952, pp. 212-250.
10. R. R. Heldenfels and W. N. Roberts—"Experimental and Theoretical Determination of Thermal Stresses in a Flat Plate," *NACA TN* 2769, 1952.
11. Josef Singer, N. Anliker, and S. Lederman—"Thermal Stress and Thermal Buckling," *WADC TR* 57-69, April 1957.
12. G. Horvay—"Thermal Stresses in Rectangular Strips," *Journal of Applied Mechanics*, Vol. 1, March 1953, p. 7.
13. G. Horvay and J. S. Born—"Tables of Self-Equilibrant Changes," *Journal of Applied Mechanics*, Vol. 33, January 1955.
14. G. Horvay—"Thermal Stresses in Rectangular Strips—I," *Proc. of 2nd National Congress Applied Mechanics*, ASME, 1954.
15. J. S. Born and G. Horvay—"Thermal Stresses in Rectangular Strips," *Journal of Applied Mechanics*, September 1955, pp. 401-406.

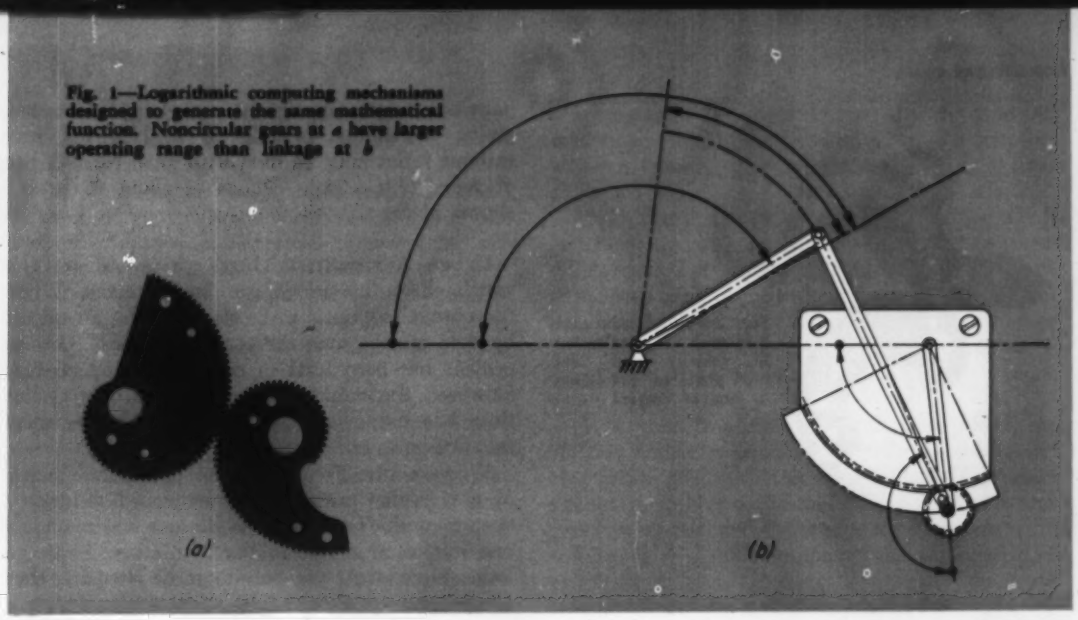


Fig. 1—Logarithmic computing mechanisms designed to generate the same mathematical function. Noncircular gears at *a* have larger operating range than linkage at *b*

Designing and using

Noncircular Gears

to generate mathematical functions

By FREDERICK W. CUNNINGHAM
President
Cunningham Industries Inc.
Stamford, Conn.

NONCIRCULAR gears have been known and used for a great many years. However, they usually have been considered mathematical curiosities rather than practical machine elements.

Actually, these gears can be designed to generate almost any mathematical function that does not reverse its slope or have discontinuities. Velocity ratio of the driven and driving gears can vary by more than 50 to 1 as the driver rotates through one revolution. In addition, they have the usual properties of high operating efficiency and accuracy common to gears. In contrast, comparable cam arrangements usually have pressure-angle troubles and lost-motion errors in the follower systems, and frequently require additional servos.

One reason for the neglect of these potentially useful machine components has been the lack of a source of supply for any but simple elliptical gears. However, with the development of a control system for a gear shaper, which will generate any practical form of gear from instructions on a roll of paper tape, this reason has been eliminated.

Another reason for neglect has been the lack of knowledge of the properties and potentialities of these gears. Purpose of this article is to provide the designer with enough information to evaluate the practicality of these gears in specific applications and to make a preliminary design adequate for lay-out purposes.

Advantages and Limitations: In mechanical computers, linkages have been found effective for various function-generating applications. However, these linkages are not straightforward in design, and rarely give kinematically exact solutions. Noncircular gears, on the other hand, can usually be developed to give kinematically exact solutions. A logarithmic computing linkage[1] and a noncircular gear pair for generation of the same function over a somewhat larger range are shown in Fig. 1.

Kinematically, a cam can provide any desired motion. In practice, though, cams are subject to certain operating limitations. A typical pair of noncircular

[1]References are tabulated at end of article.

Fig. 2—Noncircular-gear pair with large variation in velocity ratio and high angle of inclination to line of centers

gears will have an arc length from 3½ to 4 times its maximum radius, giving a travel about 8 times as great as that for a cam of the same size. If tolerances are the same for each system, the noncircular-gear pair will position an output shaft 8 times more accurately. Moreover, the drive consists of two spur gears on parallel shafts, with attendant assembly advantages.

There are two important differences in the operating characteristics of a pair of noncircular gears and a cam. As a cam rotates, its follower operates cyclically, returning to its original position each revolution. In noncircular-gear drives, on the other hand, the driven shaft can be rotated continually in one direction. However, in many computing applications this is unimportant, since neither input nor output is driven continuously.

The other difference is that in a noncircular-gear pair output speed with respect to input speed can never reach zero. In fact, it is inadvisable to employ a speed variation from high to low of more than about 35 to 1, made up of a speed reduction of 7 to 1 and a speed increase of 5 to 1. With two pairs of gears in cascade, this can almost be squared, giving a variation of 1225 to 1. However, such extreme ratios must be used with great care. A pair of gears with a ratio change of about 40 to 1 is shown in Fig. 2.

Design Alternatives: There are several ways in which these limitations can be overcome. Where the output motion is to be slow or zero, a cam can be used to take over the control function. This expedient has been used in certain printing presses.[2] However, the motion produced is still not cyclical since the output shaft does not reverse its travel to return to its initial position.

When a true cyclical motion is required, a pair of noncircular gears can be employed to drive a simple crank. This will provide one maximum and one minimum condition per revolution. Phase relationship of these two points can be altered to meet almost any requirement by varying the design of the noncircular gear pair. One example of this approach uses elliptical gears with a crank to obtain a quick-return motion, Fig. 3.[3]

A still more flexible arrangement requires the addition of a mechanical differential. With this type of system, which will be discussed in greater detail later, there are few limitations on the nature of the output motion.

Gear shape is also limited by another consideration. The common tangent to the pitch lines must not make an excessive angle with the normal to the line of centers. Maximum permissible angle will depend on such factors as allowable error and load. In extreme cases, the gears may come out of mesh for one direction of rotation. Limiting this angle to 30 deg for power transmitting gears has been recommended by one authority,[4] but this is a rather conservative value.

This limitation is exceeded by the pair of gears shown in Fig. 4.[4] However, these gears could not be made by any of the production methods currently in use. Certain portions of the gears shown

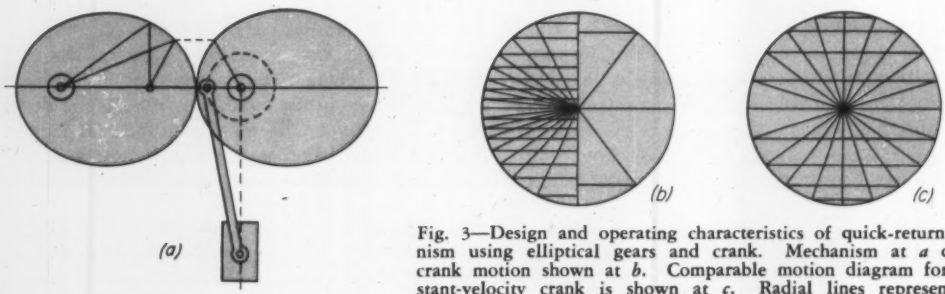


Fig. 3—Design and operating characteristics of quick-return mechanism using elliptical gears and crank. Mechanism at *a* develops crank motion shown at *b*. Comparable motion diagram for a constant-velocity crank is shown at *c*. Radial lines represent crank positions at equal time intervals

in Fig. 2 also exceed the 30-deg limit but these gears can be, and have been, produced by present methods.

If the function to be generated involves an excessive angle or too small a radius for one of the gears, another possible approach involves the use of a pair of gears designed on the basis of a suitably weighted average of input-output requirements. Accessory mechanisms can then be used to modify the motion characteristics to produce the desired relationships.

Application Considerations: Function generators have found wide application in instrumentation work. Common requirements include the generation of quantities such as trigonometric, ballistic, logarithmic, and exponential functions, as well as others. In many computers, nonlinear potentiometers have been employed for this purpose. However, greater accuracy can be obtained by using a pair of noncircular gears to drive a linear potentiometer. This arrangement also offers certain other advantages stemming from the greater convenience of working with linear, rather than nonlinear, potentiometer units.

Often an induction potentiometer,[5] an electrical resolver, or an ordinary synchro will give better results than a resistance potentiometer when used with noncircular gears as a function generator. Resistance potentiometers have a long operating life but are subject to wear and eventual loss of accuracy. In the resolver, wear is confined to the slip rings and does not affect the unit's accuracy.

Potentiometers often have been used as multipliers. Compensation of loading errors in such devices by suitable taps has received considerable attention in the literature. To keep residual scallop errors small, load impedance must be large in comparison to the resistance of the loaded potentiometer. If such a unit is linearized in the loaded state by noncircular gears, a much lower load resistance can be used and the scallops will be eliminated. This arrangement will permit the use of a third potentiometer to obtain the product of three quantities without entering the region of intolerable phase shifts.

Many functions of two or more variables can be generated by combinations of noncircular gears and differentials. For example, a multiplier can be made with three pairs of logarithmic gears and a differential, Fig. 5*a*. The range of this multiplier is limited. Best results are obtained when range of a pair of logarithmic gears is restricted to a velocity ratio of about 15 to 1.

However, if two more differentials are added, Fig. 5*b*, this limitation is removed, and negative as well as positive quantities can be handled. If x and y are the quantities to be multiplied, the logarithmic gears are so zeroed that the outputs are log $(x + a)$ and log $(y + b)$. The output of the antilogarithmic pair is $(x + a)\ (y + b) = xy + bx + ay + ab$. Quantity $bx + ay$ is then subtracted through a dif-

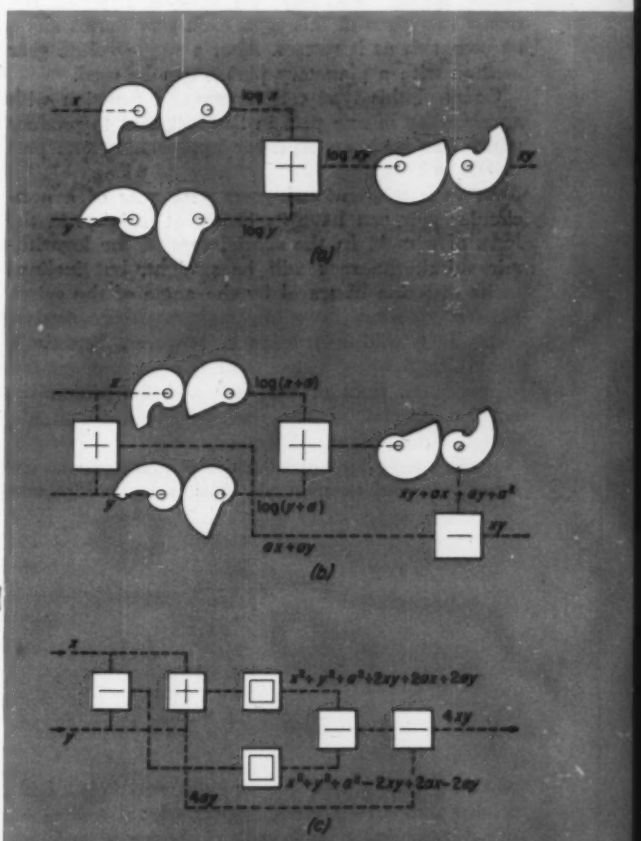


Fig. 5—Multiplier systems using noncircular gears in combination with mechanical differentials. Arrangement at *a* has limited range and can handle only positive inputs. Extended-range multiplier at *b* has two additional differential units and can handle negative as well as positive quantities. Square-law multiplier at *c* uses squaring gears to generate functions and differentials to control working range of gears

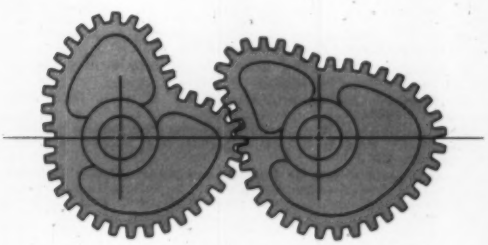


Fig. 4—Noncircular gears in which angular relationships between pitch lines and line of centers exceed practical design limits. These gears could not be made by present production methods

ferential element and the *ab* term is removed by proper zeroing of the output shaft.

Another type of multiplier can be made with squaring gears, Fig. 5c. Here again differentials are used to remove the regions of zero and negative velocity from the working range of the gears.

Gear Design: In the design of noncircular-gear function generators, the desired functional relationship should always be spread over as large an angle as possible. This practice improves the accuracy and reduces the steepness of the gears.

Thus, if a resolver were to be used as a linear potentiometer, the sine function from −45 to +45 deg might be required. This range could be spread over a gear operating angle of ±180 deg. Cusps would be introduced in the gears, but a very slight modification of the gear shape in the neighborhood of the 45-deg point would take care of this condition.

When greatest possible accuracy is required, noncircular gears can be made in a form resembling a volute spring. Normally, an idler is required between two gears of this type; each gear moves along its own axis as it rotates. Also, a single volute gear meshed with a planetary pinion can be used.

Gears of this type can represent a function with an accuracy of one part in 250,000, and to produce multipliers with an accuracy approaching one part in 100,000.

As with conventional gears, one gear of a noncircular pair can have its center at infinity, in the form of a rack. In the special case of the logarithmic spiral, the rack will be straight, but inclined to its direction of travel by the angle of the spiral, Fig. 6*a*. In other cases, the rack may be curved in form. It is still a true rack, however, because it travels in a straight line, and the point of contact of the pitch lines of the rack and the pinion lies on the normal to the line passing through the center of the pinion.

Sometimes a pair of noncircular gears can be designed by analytic methods. Basic relationships are:

$$r_\theta = \frac{\frac{d\phi}{d\theta}}{1 + \frac{d\phi}{d\theta}}$$

$$r_\phi = 1 - r_\theta = \frac{1}{1 + \frac{d\phi}{d\theta}}$$

where θ and ϕ are the angular rotations of the driving and driven gears, respectively; r_θ and r_ϕ are the corresponding pitch radii of the gears; and center distance is unity.

This approach may not be feasible if analytic representation of the function to be generated is involved or unknown. The alternative is to work from a simple table of corresponding values of the two variables to obtain an approximate but adequate solution. Basically, the procedure involves

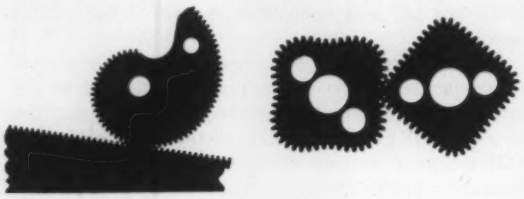


Fig. 6—Special noncircular gear forms showing, *a*, rack and pinion and, *b*, gears designed for continuous rotation

determining a polynomial expression for the rotation of one gear with respect to the other over a small range of motion. This expression is then differentiated and the radius determined for the midpoint of the range considered. The next point is then computed from another small range which is usually overlapping. The method of least squares may be employed to smooth the data. Programs have been prepared for performing these calculations with several electronic computers, most recently, with the LGP-30.[6] This procedure does not lead to any accumulation of errors.

It is ordinarily advisable to make rough design calculations with a slide rule or desk calculator, and to plot the forms of the gears on polar co-ordinate paper. This step may disclose difficulties in the action of the gears or their production. In the cutting operation on a gear shaper, a cutter in the form of a round gear or pinion is effectively rolled along the pitch curve of the gear being produced. There must be no interference of the cutter with other parts of the gear. For convenience, this preliminary calculation can be made on the basis of a unit center distance.

In most cases, the gears need not be capable of continuous rotation. However, where such rotation is necessary, the total arc length for a revolution must be made a multiple of the effective circular pitch. This requirement can often be met without adjustment of the center distance. Fig. 6*b* shows a pair of gears which rotate continuously.

References

1. A. Svoboda—*Computing Mechanisms and Linkages*, McGraw-Hill Book Co. Inc., New York, N. Y., 1948, p. 221.
2. H. E. Peyrebrune—"Application and Design of Noncircular Gears," MACHINE DESIGN, Vol. 25, No. 12, December, 1953, pp. 185-193. (Also, *Transactions of First Conference on Mechanisms*, The Penton Publishing Co., Cleveland, Ohio, 1953.)
3. G. B. Grant—*A Treatise on Gear Wheels*, 19th Edition, Philadelphia Gear Works, Philadelphia, Pa., 1947.
4. G. W. MacCord—*Kinematics*, John Wiley & Sons, Inc., New York, N. Y., 1883.
5. F. W. Cunningham—"Employing Computer Components on Machine Control," Part 1, MACHINE DESIGN, Vol. 22, No. 6, June, 1950, pp. 133-136.
6. *Electronic Digital Computer Designs and Automatically Controls Production of Non-Circular Gears*, LGP-30 Information Bulletin 701, Royal-McBee Corp., Data Processing Div., Port Chester, N. Y., 1958.

Acknowledgment

This article is based on a paper presented at the Fifth Conference on Mechanisms, cosponsored by Purdue University and MACHINE DESIGN, October 13-14, 1958.

Charts and equations for a simplified "short-cut" approach to

HELICAL-SPRING DESIGN

By J. HIRSCHHORN
School of Mechanical Engineering
University of New South Wales
Sydney, Australia

PROCEDURES and charts presented in this article were developed to provide a simple, rapid approach to design of helical springs without trial-and-error calculations. The charts, which take into account the Wahl correction factor and the relationship of wire diameter to working stress, give a direct solution regardless of spring diameter.

The design method outlined here is applicable to both compression and extension springs, with one qualification. No allowance has been included for initial tension in extension springs. However, initial tension does not affect the load-carrying capacity of the spring. It only acts to reduce the total deflection of the spring by an amount equal to the deflection which an "open" spring would experience under a load equal to the initial tension.

Nomenclature

C =	Spring index $= D_m/d$
D_i =	Inside diameter of spring, in. $= (C-1)d$
D_m =	Mean diameter of spring, in.
D_o =	Outside diameter of spring, in. $= (C+1)d$
d =	Diameter of circular cross-section wire or thickness of square cross section wire, in.
G =	Torsional modulus of elasticity, psi
K,K' =	Spring design coefficients, (Equations 4 through 11)
L =	Free length of spring, in.
N =	Number of active coils
P =	Applied load, lb
S =	Stress factor
Y =	Wahl stress correction factor
Δ =	Total deflection of spring under load P, in.
δ =	Deflection per coil under load P, in.
τ =	Working stress, psi
τ_p =	Permissible stress, psi
τ_y =	Torsional yield stress, psi

Permissible Wire Stress: Since stress capacity of a wire varies inversely with its size, permissible stress values are frequently related to the wire diameter. The following relationships have been found to give satisfactory results:

$$\tau_p = \frac{S}{d^{1/4}}, \quad d \geqq 0.092 \text{ in.} \tag{1}$$

$$\tau_p = 1.81S, \quad d < 0.092 \text{ in.} \tag{2}$$

where symbols are defined in Nomenclature.

Value of stress factor S is a function of spring material and loading conditions. It is numerically equal to the allowable stress for a wire of 1-in. diameter. For carbon-steel springs, and generally static applications, such as spring supports, friction clutches, brakes, governors, etc., S = 50,000 to 55,000 and, sometimes, even 60,000. For materials other than carbon steel and static loading conditions, stress factor S is directly proportional to the ratio of torsional yield stresses.

Under dynamic loading conditions, the value of S decreases. It may be found by multiplying the static value of S by the ratio of the fatigue limit for the particular load range to the torsional yield stress.

For S = 50,000, typical stress values given by Equations 1 and 2 are: d = 1 in., τ_p = 50,000 psi; d = ½ in., τ_p = 59,400 psi; d = ⅛ in., τ_p = 84,100; and $d \leqq 0.08$ in., τ_p = 90,500 psi.

Working-Stress Relationships: For compression and tension springs using wire of circular cross section,

$$\frac{\pi d^3 \tau}{16} = \frac{PD_m Y}{2} \tag{3}$$

In design, τ should be made equal to τ_p for best

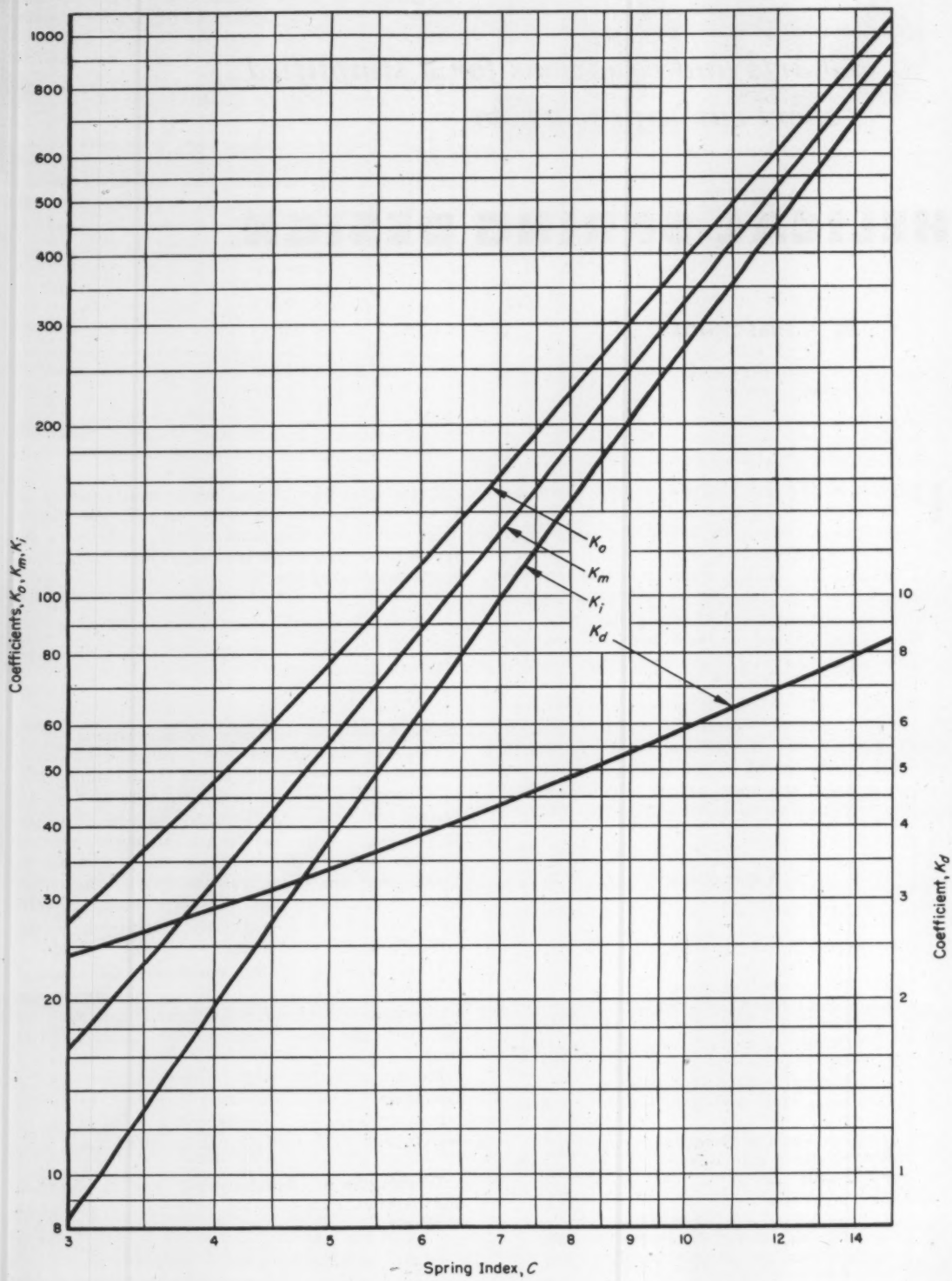


Fig. 1—Spring design coefficients for wire diameter $d \geqq 0.092$ in. Plots, which are based on stress factor $S = 50{,}000$, represent the solutions to Equations 4 through 7

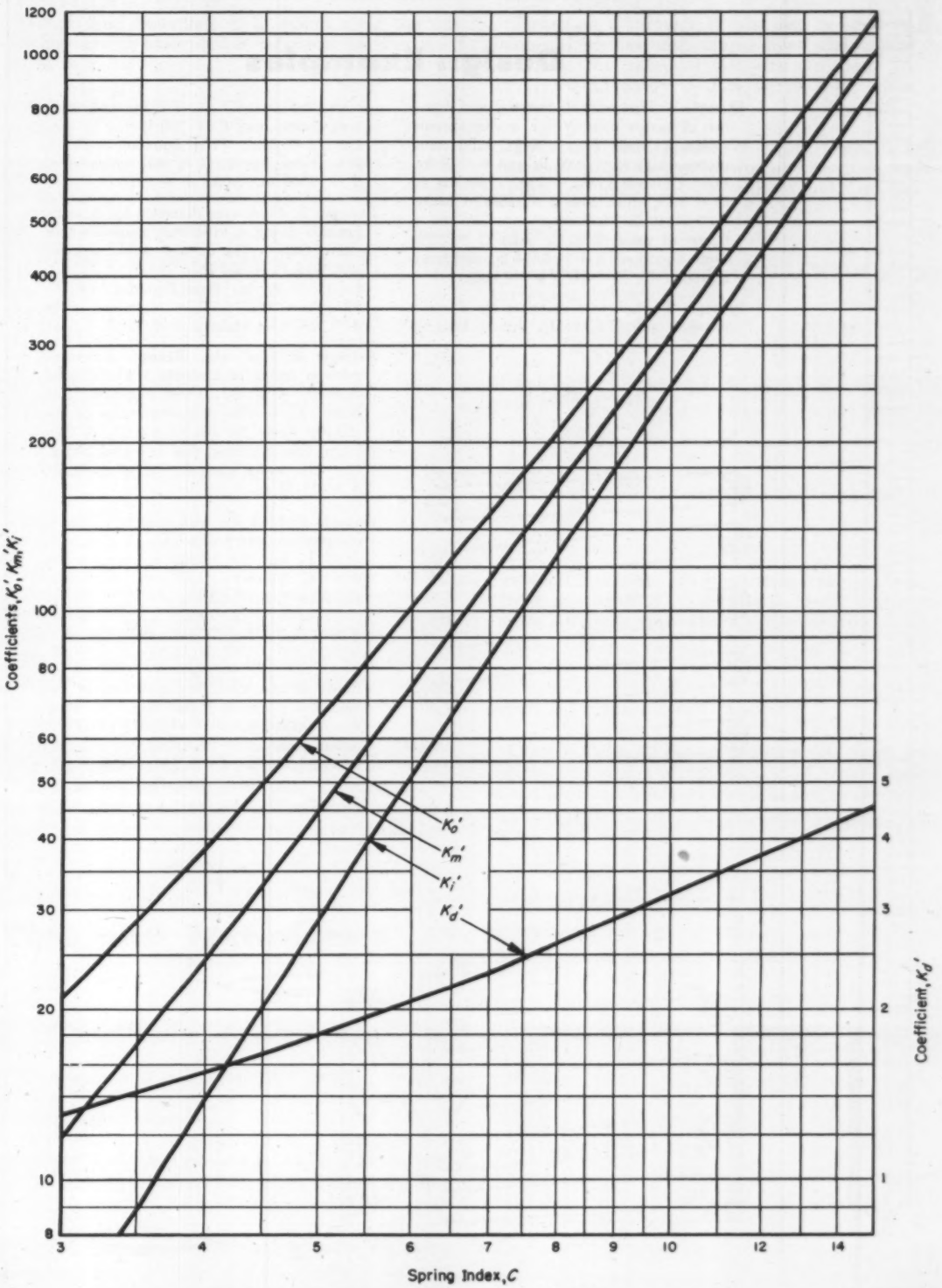


Fig. 2—Spring design coefficients for wire diameter $d < 0.092$ in. Plots, which are based on stress factor $S = 50{,}000$, represent the solutions to Equations 8 through 11

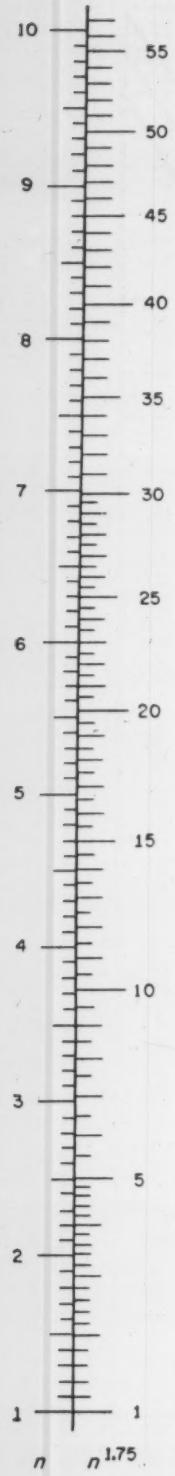


Fig. 3 — Scale for rapid calculation of exponential quantities in Equations 4 through 7 (Fig. 1)

Design Examples

Example 1: Find wire diameter d and number of active coils N for a compression spring, *a*, where $D_m = 6$ in., solid compression load $P = 1000$ lb, and $\Delta = 8$ in.
From Equation 5, $K_m = 230$. From Fig. 1, $C = 8.75$, which gives $d = 0.686$ in. Make $d = 11/16$ in.
Corrected value of spring index $C = 8.73$. From Equation 13, $\delta = 0.694$ in., and from Equation 15, $N = 11.5$ active coils.

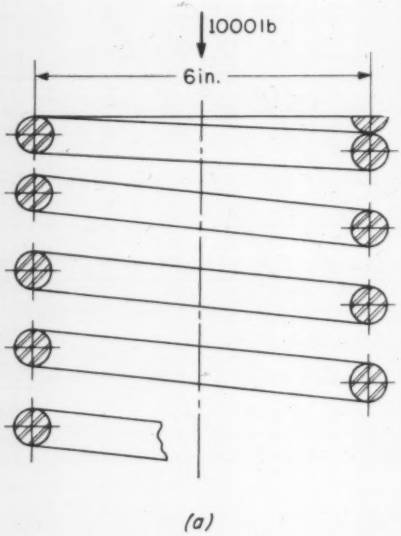
Example 2: Find wire diameter for a compression spring, *b*, to fit into a housing where housing ID $= 3\frac{1}{8}$ in. and solid compression load $P = 250$ lb.
Let $D_o = 3$ in. From Equation 6, $K_o = 273$. From Fig. 1, $C = 8.7$, which gives $d = 0.309$ in. Make $d = 5/16$ in.

Example 3: Find wire diameter for a compression spring, *c*, to fit over a sleeve where sleeve OD $= 3\frac{3}{8}$ in. and solid compression load $P = 450$ lb.
Let $D_i = 3\frac{1}{2}$ in. From Equation 7, $K_i = 199$. From Fig. 1, $C = 9$, which gives $d = 0.437$ in. Make $d = 7/16$ in.

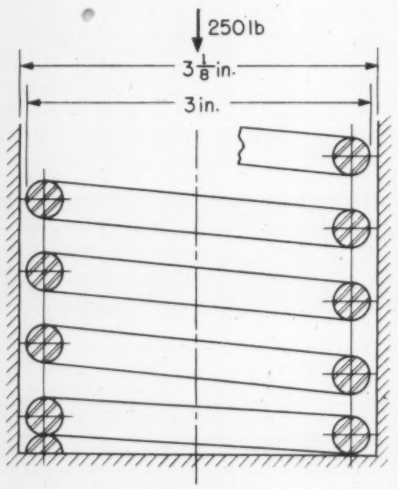
Example 4: Find wire diameter for compression spring of Example 3 where stress factor $S = 60{,}000$. From Equation 7, as before, $K_i = 199$. Corrected value of coefficient $K_i = 199\ (60{,}000/50{,}000) = 239$. From Fig. 1, using this corrected value, $C = 9.6$, which gives $d = 0.407$ in. Make $d = 13/32$ in.

Example 5: Find the load capacity P for a compression spring where $D_m = 4$ in. and $d = \frac{1}{2}$ in. By definition, spring index $C = 8$. From Fig. 1, $K_m = 184$. From Equation 5, $P = 620$ lb.

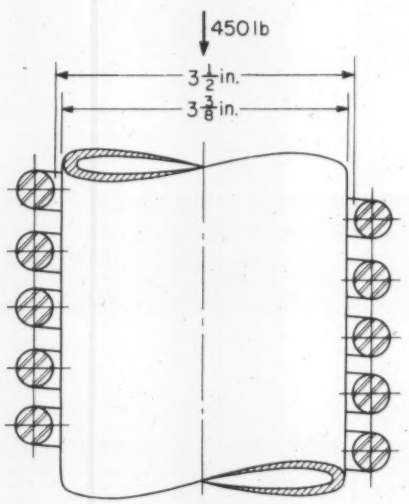
Example 6: Find the mean diameter of a compression spring to provide a load capacity $P = 150$ lb where $d = 0.25$ in.
Range of the scale in Fig. 3 can be extended to values of n less than 1 by using the relationship, $n^{1.75} = 0.0177(10n)^{1.75}$, which gives $0.25^{1.75} = 0.088$.
From Equation 4, $K_d = 5.87$. From Fig. 1, $C = 10.2$, which gives $D_m = 2.55$ in. Make $D_m = 2.5$ in.



(a)



(b)



(c)

utilization of the material.

Combining Equations 1, 2, and 3 gives the following sets of basic design relationships. For $d \geqq 0.092$ in.,

$$K_d = \frac{10{,}000}{P} d^{1.75} \quad (4)$$

$$K_m = \frac{10{,}000}{P} D_m^{1.75} \quad (5)$$

$$K_o = \frac{10{,}000}{P} D_o^{1.75} \quad (6)$$

$$K_i = \frac{10{,}000}{P} D_i^{1.75} \quad (7)$$

For $d < 0.092$ in.,

$$K_d' = \frac{10{,}000}{P} d^2 \quad (8)$$

$$K_m' = \frac{10{,}000}{P} D_m^2 \quad (9)$$

$$K_o' = \frac{10{,}000}{P} D_o^2 \quad (10)$$

$$K_i' = \frac{10{,}000}{P} D_i^2 \quad (11)$$

These coefficients are a function of stress factor S and spring index C. Plots of these coefficient values for spring indexes from 3 to 15 and $S = 50{,}000$ are given in the charts in Fig. 1 and 2. Plots in Fig. 1 represent the solutions to Equations 4 through 7, those in Fig. 2 to Equations 8 through 11. A scale for rapid calculation of exponential quantities in Equations 4 through 7 is provided in Fig. 3.

Although these charts are based on $S = 50{,}000$, they also may be used for other stress factor values. Coefficient values will be directly proportional to the ratio of stress factors. Calculation of corrected coefficient values is demonstrated in the design examples presented later.

Equations 4 through 11 can also be used in the design of springs with square cross section wire by changing the value of the constant from 10,000 to 11,000. Quantity d then becomes the value of wire thickness.

Deflection and Number of Active Coils: A basic relationship for design of round-wire compression springs and tension springs without initial tension is:

$$\delta = \frac{8PD_m^3}{Gd^4} \quad (12)$$

For carbon steel wire with $G = 11.5(10)^6$ psi, this expression becomes

$$\delta = \frac{0.70C^3P}{10^6 d} \quad (13)$$

If the wire is of square cross section and G has the same value as before,

$$\delta = \frac{0.49C^3P}{10^6 d} \quad (14)$$

Number of active coils can be determined from

$$N = \frac{\Delta}{\delta} \quad (15)$$

Lateral Buckling: To prevent lateral buckling of compression springs under axial loads, maximum spring deflection should satisfy the condition,

$$\frac{\Delta}{L} < 0.70 - 0.04\left(\frac{L}{D_m}\right)^2 \quad (16)$$

which was adapted from Timoshenko*.

Design Calculations: Application of these procedures and charts in the solution of typical spring design problems is demonstrated in *Design Examples*.

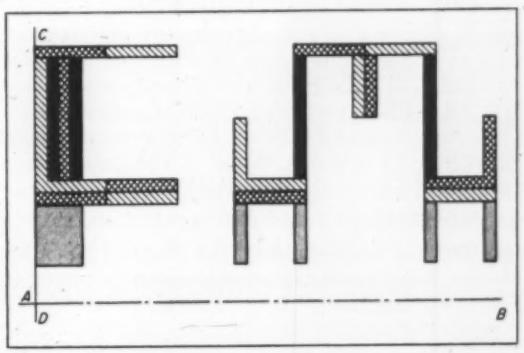
*S. Timoshenko—*Theory of Elastic Stability*, McGraw-Hill Book Co. Inc., New York, 1936, p. 167.

Tips and Techniques

Simplification of Cross Sections

Here's a useful technique which reduces complex cross sections to equivalent simple ones for moment of inertia calculations.

Draw line *CD* perpendicular to a reference axis *AB*. Next, draw lines parallel to *AB*, so that the lines cut the original cross section (right figure) and line *CD*. The number of lines and position depend upon the configuration of the cross section, but are usually selected to pass through points where the shape changes. Finally, lay off and add, against the axis *CD*, the lengths of segments in the original cross section which are bounded by each pair of parallel lines. The configuration which results (left figure)



is equivalent to the original cross section.—S. IVTSAN, *Winterthur, Switzerland.*

Industrial Laminates

from the company that really knows the electrical and electronics industry—General Electric

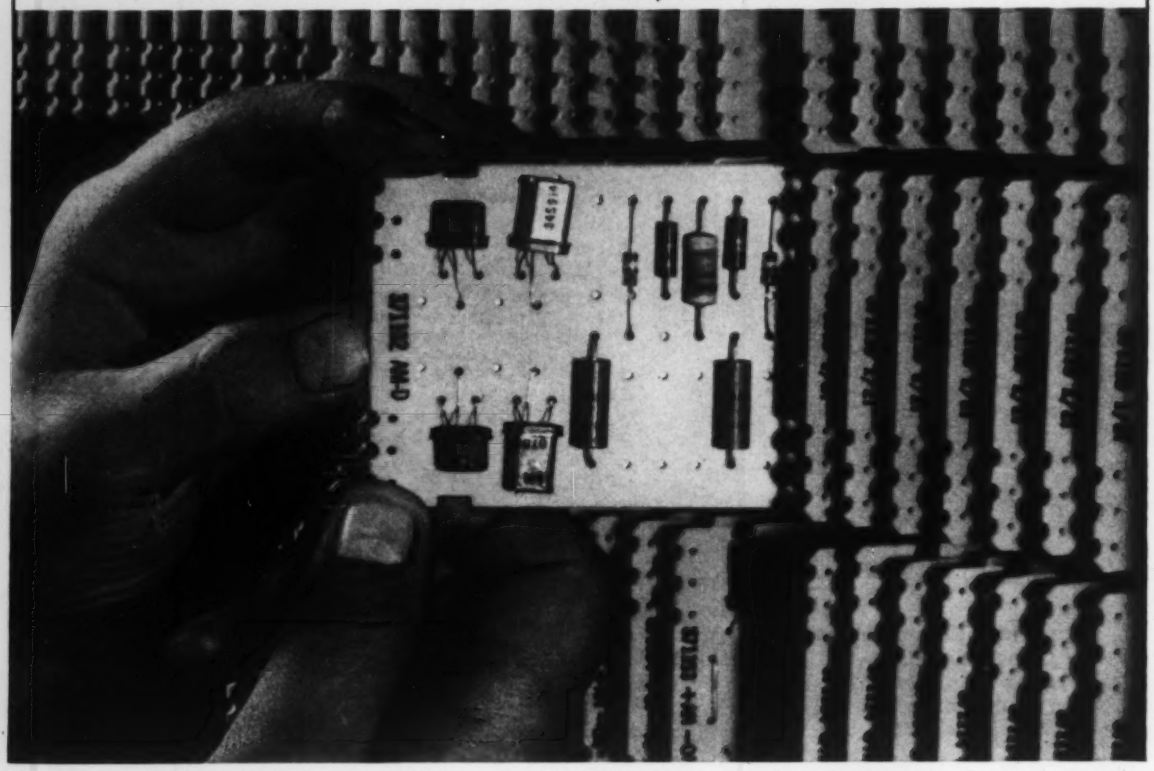


Photo of 729 Model III Tape Drive Unit (part of 705 Model III Data Processing System) courtesy of International Business Machines Corp.

Textolite® Grade 11574 exceeds every NEMA XXXP requirement . . .

Self-extinguishing epoxy paper laminate for high-reliability computer circuits

General Electric Textolite Grade 11574 will not support combustion . . . has unsurpassed punchability at room temperatures

Textolite Grade 11574 was specifically designed for computer applications where very high reliability is demanded. Its superior electrical and mechanical properties easily outperform NEMA standards without the high cost and difficult fabrication problems of glass-based laminates. Some of the outstanding properties of Grade 11574 include:

- **Self-extinguishing**—flame dies within 1 second.
- **Cold punches best**—pierced and blanked holes are cleaner, more precise than any laminate tested in G-E laboratories.
- **Cyanide resistant**—maximum reliability in all etching and plating processes.
- **High insulation resistance**—1,000,000 megohms IR after 96 hours at 90% humidity and 35°C.
- **High flexural strength**—over 26,000 psi, twice the NEMA standard for XXXP grades.

Consult Sweet's Product Design File, Cat. 2b/Gen, for technical data on the complete line of Textolite laminates. Or for additional information—or expert help with special problems—call or write: *Technical Service, Laminated Products Department, Section MD-92. General Electric Company, Coshocton, Ohio.*

Textolite®
INDUSTRIAL LAMINATES
GENERAL ELECTRIC

DESIGN ABSTRACTS

materials

Ceramic Coatings For Thermal Insulation

A. V. Levy, Marquart Aircraft Co.

A report on the status of the art of ceramic coatings as applied to aircraft and missile power-plant parts. Various materials suitable for flame-spray application and effective thicknesses are covered. Several new reinforced-ceramic coatings are expected to extend the application range of flame-sprayed coatings. With heating sources such as the plasma jet, coatings for service in the 4000 to 6000-F temperature range seem feasible. Types and configurations of reinforcing media include wire mesh of stainless steel and molybdenum, expanded metal from mild steel, stainless steel, and molybdenum, corrugated metal strips of the same materials, and fibers of ceramic materials. Types of ceramics being reinforced are sodium silicate base composites, phosphate-bonded alumina, zirconia, chromia, and pure alumina and zirconia.

SAE paper 4T, Annual Meeting, Detroit, Mich., January, 1959; 10 *pp.*

Solid-Film Lubricants For Use Above 1000 F

R. E. Crump, Electrofilm Inc.

A progress report on a high-temperature solid-film lubricant composed of synthetic graphite, lead oxide, and a porcelain-enamel binder. Water, with a small amount of wetting agent, is found to be satisfactory for thinning the solid mixture to a fluid consistency for ease of application to bearing surfaces. A light sand blast provides a surface with enough developed area to insure better adhesion of the lubricant than a surface not sand blasted. The most successful formulations are those which use so little dry, unfired porcelain enamel that the end product is not glass-like on the surface but is rather gray-black in appearance when graphite and lead oxide are used as lubricants. Mechanism of friction and wear is covered briefly, and methods of test and equipment are discussed. Property data include melting or oxidation points of lubricant solids, structure of the solids, and coefficient of friction values for solid-film lubricants and various steel and titanium alloys.

SAE paper 4S, SAE Annual Meeting, Detroit, Mich., January, 1959; 12 *pp.*

Choosing Rubber for Use with Synthetic Hydraulic Fluids

E. A. Webster and R. G. Larkin, Douglas Aircraft Co.

Treatment of two methods of predicting the compatibility of a basic gum or family of polymers and a particular fluid. The solubility parameter concept is considered to be of more value than the similarity rule which states that "like dissolves like." The solubility parameter concept is, in part, a quantitative index of the resistance of a rubber-like polymer to the entire spectrum of fluids. Hardness, ultimate tensile strength, and compression set of rubbers are defined, and performance requirements of several materials in actual application are discussed. Problems of O-ring seals are emphasized. Compatibility of elastomers with various hydraulic fluids is shown as per cent of swell.

SAE paper 9T, SAE Annual Meeting, Detroit, Mich., January, 1959; 12 *pp.*

Materials Problems In Rocket Engines

D. E. Roda, North American Aviation Inc.

A general treatment of material requirements and problems encountered in the design, fabrication, and testing of liquid-propellant rocket engines. Problems covered are those of thermal expansion, low-temperature mechanical properties, fatigue of gear teeth, strength and quality of aluminum castings, incompatibility of protective coatings and rocket fuels, and lubricant failure.

SAE paper 4R, from SAE Annual Meeting, Detroit, Mich., January, 1959; 6 *pp.*

mechanical

Bearing Tests with a Machine Producing Impulsive Loading

A. E. Russell, The British Internal Combustion Engine Research Association

A report on the development of a machine for testing bearings under an impulsive type of load similar to that produced in compression-ignition engines. Such a machine facilitates accurate measurement of actual load, replacement of damaged journals, ease of bearing materials change, and ease of bearing examination. Procedure for assessing load capacity of bearings is

described, and relative load-carrying capacities of various bearing materials are given. Effects of changes in lubrication conditions and misalignment are included. Bearings having the highest load-carrying capacities are copper-lead lined steel shells, solid aluminum-alloy shells, and solid bronze shells. Copper-lead linings produced by the sinter process have higher load-carrying capacity than cast copper-lead lining.

Prepared for the Institution of Mechanical Engineers (Great Britain); 12 pp.

Response of a Loaded Hydraulic Servomechanism

D. E. Turnbull, British Hydromechanics Research Association

Effects of various types of loads on dynamic behavior of a hydraulic system for step and sinusoidal input signals. Analytical solutions to most of the response equations are obtained, but graphical methods are occasionally used. Although many significant contributions have been made to the field of hydraulic position-control systems in the past, little attention has been given to some of the more important nonlinearities which are introduced when single-stage systems are loaded. The paper analyzes individual and combined effects of some of the more common types of load which include a constant load (friction); a load proportional to displacement (spring); a velocity-dependent load (viscous); a load proportional to the square of velocity (orifice or dashpot); and, what is probably most common, an inertial load. An understanding of the action of the servo under these individual and combined loads enables prediction of the behavior of more complicated systems.

Prepared for the Institution of Mechanical Engineers (Great Britain); 10 pp.

Derivation of a Cam Contour For Minimum Stress

F. T. Turner, The Western Union Telegraph Co.

An approach to the design of cams which yields a contour for minimum stress and noise. Detailed development of the cam is covered in terms of a specific application. The cam's follower and associated mechanism are considered as a dynamic system. As such, a minimum of stress and noise results if the motion of the system is free from frequency components higher than the minimum required to accomplish the necessary travel in the required time. This condition is satisfied if the acceleration itself is a sine curve.

Western Union Technical Review, Volume 13, No. 1, January, 1959; pp. 14-16.

processes

Coated-Abrasive Machining

J. M. Pitblado, Minnesota Mining and Mfg. Co.

A brief discussion on the applicability of machining with available forms of coated abrasives. Considerations of stock removal and resultant finishes are covered. Cutting rates for various materials are included.

ASTE paper 146, American Society of Tool Engineers Semi-Annual Meeting, Los Angeles, October, 1958; 9 pp.

techniques

Correlation of High Temperature Creep and Rupture Data

H. Conrad, Westinghouse Electric Corp.

Correlation of high-temperature creep and rupture data for several superalloys and an aluminum alloy. Correlation is by means of a proposed equation which is in better agreement with experimental and theoretical information than those most frequently used. Equations most commonly used in correlating creep and rupture data have been found to possess one or more major shortcomings. Hence, the proposed equation.

ASME paper 58-A-96, ASME Annual Meeting, New York, December, 1958; 10 pp.

Synthesis of Four-Bar Linkages In Terms of Velocity Ratios

P. Barkan and E. J. Tuohy, General Electric Co.

Four-bar linkage systems synthesized in terms of their velocity ratios at two or three positions of the input crank. The two-point synthesis problem is readily solved by graphical or longhand mathematical techniques. The method lends itself to computer solution for the three-point problem and is valuable for determining the best match of a desired function over a specified range of input-crank motion. Where data are incompatible with the inherent characteristics of the four-bar linkage, computations yield imaginary results.

ASME paper 58-A-115, ASME Annual Meeting, New York, December, 1958; 7 pp.

Physical Measurement— A Challenge to Engineering

A. V. Astin, National Bureau of Standards

A rather philosophical discussion of the science of physical measurement and opportunities for improved measuring techniques in various areas. For purposes of discussion, the paper divides science and technology into four arbitrary areas: Newer fields of scientific investigation such as plasma physics, established areas of research, newer fields of technology such as rocket and missile development, and established fields of technology where precision measurement may provide improved performance and reduced costs. Specific problems relating to each area include lag of development of precise techniques for producing and controlling the phenomena of ionizing radiations, difficulties with precise time and temperature measurements, lack of new measurement principles in space technology, inadequate measurement instrumentation for specific automation problems, and difficulties in reliability, force measurement, and dimensional measurement in the area of established technology.

SAE paper 21R, SAE Annual Meeting, Detroit, Mich., January, 1959; 7 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

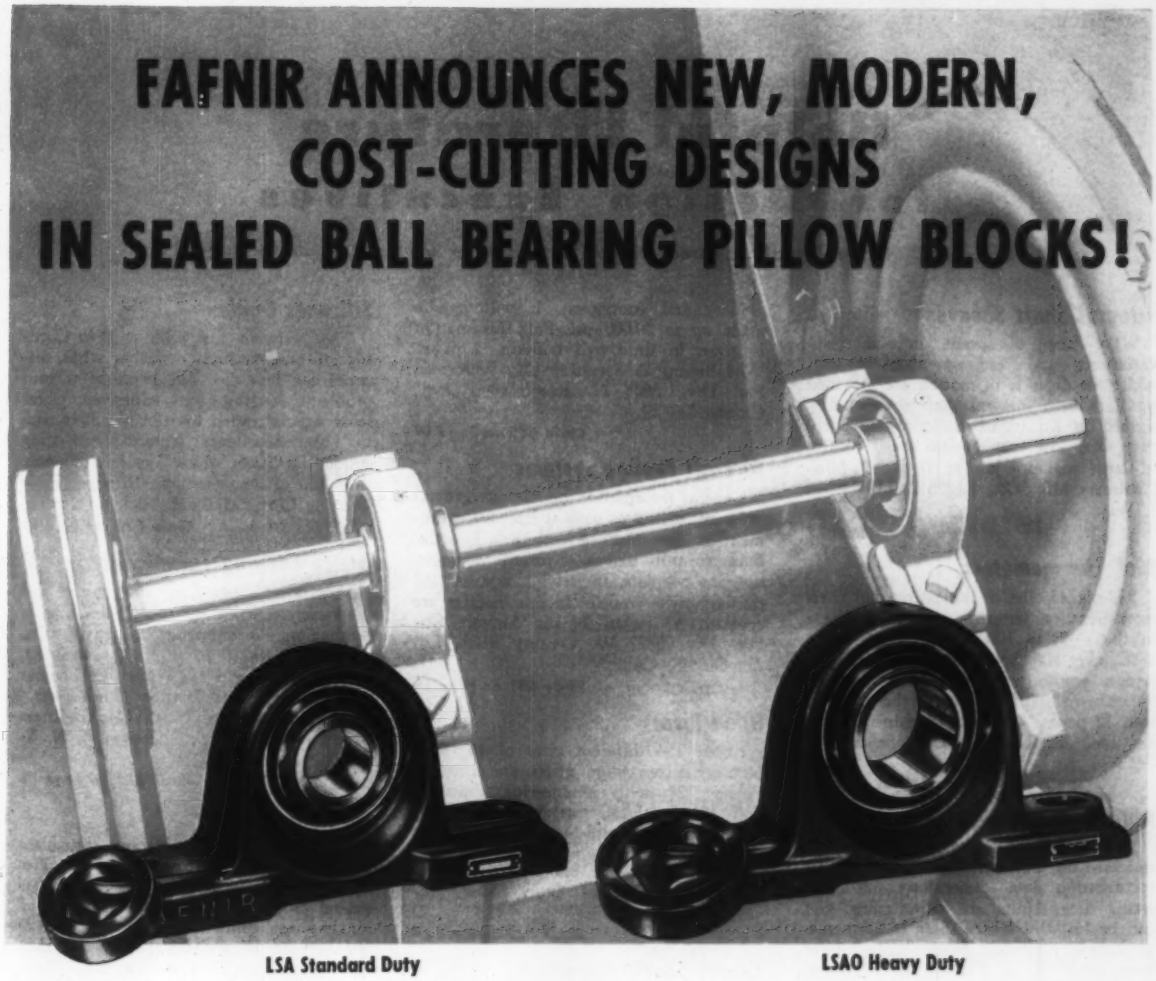
The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, SW 1.

Western Union Technical Review, The Western Union Telegraph Co., 60 Hudson St., New York 13, N. Y.

ASTE—American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; papers 25 cents to members, 50 cents to nonmembers.

FAFNIR ANNOUNCES NEW, MODERN, COST-CUTTING DESIGNS IN SEALED BALL BEARING PILLOW BLOCKS!



LSA Standard Duty

LSAO Heavy Duty

Protection, economy, design-appeal featured in new LSA and LSAO standard and heavy duty units

Introduction of Fafnir LSA and LSAO pillow blocks opens new opportunities for improving both machine performance and styling, and reducing costs in standard and heavy duty applications.

Equipped with integral seal, wide inner ring ball bearings, the units are positively protected against contaminants and loss of lubricant. Fafnir-originated self-locking collars permit fast, easy, cost-cutting installation. Moreover, though the new series are made to the same base-to-center height dimensions and bolt-hole spacings as corresponding sizes in Fafnir's SA and SAO series, they are available at lower initial cost.

Housings are solidly built and of massive, streamlined design to harmonize with modern machine styling. All units are prelubricated and have provision for relubrication, if necessary . . . come ready to mount . . . and are designed to take radial, thrust, or combined loads in any position. Write for new bulletin showing sizes, dimensions, types, features. The Fafnir Bearing Company, New Britain, Connecticut.

FEATURES

Positive Protection — Slinger-type Mechani-Seals for protection at higher speeds; contact-type Plya-Seals for slow-to-moderate speeds, dirty or wet conditions.

Extra-Sturdy Support — Wide Inner Ring Ball Bearings with deep grooves and large balls for sturdy shaft support.

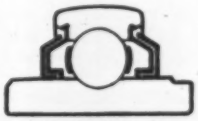
Simplest Installation — Fafnir-originated eccentric cam self-locking collar provides positive locking to shaft with twist of wrist. No machining, no mounting devices.

Self-Alignment — Spherical bearing O.D. and corresponding spherical housing seat assure self-alignment in any direction.

Modern Styling — Smoothly finished, streamlined, massive cast iron housing with machined bearing seat and base.

Plya-Seal

Integral Seal Ball Bearings



Mechani-Seal

FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA

Bearings in LSA units are Mechani-Seal type — or available optionally with Plya-Seals (RSA). LSAO series bearings are Mechani-Seal type, except those for shaft sizse 3 3/16", 3 7/16", and 3 15/16", which have Plya-Seals (RSAO).

Helpful Literature
for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Integral Shaft Sheaves

Wide range of speeds, infinite speed variations, and accurate speed control while the drive is in motion are provided by Vari-Pitch integral shaft sheaves. Described in illustrated Bulletin 20B7897B, they offer low cost stepless speed control in large machine drives. 6 pages. Allis-Chalmers Mfg. Co., Box 512, Milwaukee 1, Wis. K

Circle 625 on Page 19

Dial Thermometers

Redesigned line of indicating dial thermometers for temperature measurements in the −40 to 1000° F range is subject of Catalog 205. Specs for both direct and remote reading types are given for the Supertherm filled-system thermometer line. 12 pages. American Machine & Metals, Inc., U. S. Gauge Div., Sellersville, Pa. E

Circle 626 on Page 19

Pillow Block Bearings

Pillow block and flange bearings are reviewed in Bulletin 106 which features construction data, dimensions, and load rating data. Units are self-aligning and can be installed where there is shaft misalignment. Pillow block units have bores from ¾ to 2 15/16 in. 12 pages. Hoover Ball & Bearing Co., Ann Arbor, Mich. H

Circle 627 on Page 19

Centrifugal Castings

Large or small, uniformly close-grained, free-machining, flawless centrifugal castings can be produced by this company in all nonferrous and stainless steel alloys and in Monel according to illustrated bulletin. Production facilities, typical products, and engineering data are included. 10 pages. Wisconsin Centrifugal Foundry, Inc., Waukesha, Wis. K

Circle 628 on Page 19

Washers & Stampings

Thousands of sizes and types of washers and stampings made of practically any material in standard and special sizes and configurations are pictured and listed according to size in Catalog 40-A. Tool list is included for making round washers to customers dimensional needs. 48 pages. Wrought Washer Mfg. Co., 2100 S. Bay St., Milwaukee, Wis. K

Circle 629 on Page 19

Vibration Isolators

Sorbtex is a preformed pad material which dampens shock and isolates vibration. Resistant to oil, mildew, and abrasive action, it can be used to mount machinery and equipment. It will handle loads up to 20,000 psi. Full information is given in illustrated bulletin. 4 pages. Voss Belting & Specialty Co., Preformed Pad Div., 5645 N. Ravenswood Ave., Chicago 26, Ill. I

Circle 630 on Page 19

Aircraft Fueling Systems

General information on aircraft ground pressure fueling as well as hydrant equipment is contained in technical bulletin. Fuel control valves, hydrant adapters, hydrant couplers, underwing nozzles and military-style pressure fueling nozzles are covered. 30 pages. Parker Aircraft Co., Fuel Div., 5827 W. Century Blvd., Los Angeles 45, Calif. L

Circle 631 on Page 19

Blind Rivets

About 154 different sizes of Pin-Grip hammer-driven blind rivets are listed in Folder 227 with engineering drawings and specifications. Intended for metal-to-metal and metal-to-wood fastenings, they are made of aluminum with knurled stainless steel drive pins. 6 pages. Star Expansion Industries Corp., Mountainville, N. Y. D

Circle 632 on Page 19

Center Shock Mountings

Vibration isolation and heavy shock absorption feature of Center Bonded mountings is appraised in Bulletin 712 which also covers design, installation, performance, and specifications of both compression and shear-type mountings. 4 pages. Lord Mfg. Co., 1635 W. 12th St., Erie, Pa. F

Circle 633 on Page 19

Enclosed Switches

Revised Catalog 83c gives details of nine housing groups of metal-enclosed switches for industrial use. Explosion-proof, maintained-contact, prewired, hand-operated, and sealed switches are a few of the 99 different listings shown. 20 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 634 on Page 19

Precision Gears

Gears with tooth-to-tooth spacing accuracies of 0.0002 in. are described in Bulletin GEA-6430. They range from less than 1 in. to over 200 in. in diameter and are used in high-speed industrial, marine, aircraft power and accessory, rocket and missile, radar power and data, and guidance control gear systems. 24 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 635 on Page 19

Silicones Guide

The 1959 reference guide to Dow Corning silicone products describes what silicones can best meet the needs of various problems ranging from adhesives to release agents, resins to rubbers, dielectrics to water repellents. Expanded indexing system facilitates quick location of more than 150 silicone products. 16 pages. Dow Corning Corp., Midland, Mich. H

Circle 636 on Page 19

Office Copying Techniques

How office copying can save money and increase efficiency in purchasing, sales, production, administration, advertising, research, accounting, shipping, receiving, and engineering is explained in booklet entitled "4 Versatile Office Time-Savers." 16 pages. Eastman Kodak Co., Business Photo Methods Div., Rochester 4, N. Y. N

Circle 637 on Page 19

AC Generators

Line of explosion-resistant, brushless ac generators is featured in Booklet ACG958. Ratings of three-phase machines extend from 5 through 400 kw, and of single-phase units, from 5 through 150 kw in both 50 and 60 cycle frequencies. 16 pages. Kato Engineering Co., Mankato, Minn. J

Circle 638 on Page 19

Sight Flow Indicators

Specification Sheets 10E1200 and 10E1215 describe sight flow indicators and the sight flow indicating check valve. Data cover materials of construction, operational limits, mountings, and connections. 2 pages each. Fischer & Porter Co., 842 Jacksonville Rd., Hatboro, Pa. E

Circle 639 on Page 19

Gearmotors

Fractional horsepower geared motors, turntables, transmissions, and cup dispensers are described and illustrated and their specifications given in series of bulletins supplied in a folder. Dimensional drawings are included. Merkle-Korff Gear Co., 213 N. Morgan St., Chicago 7, Ill. J

Circle 640 on Page 19

Swivel Pipe Joint

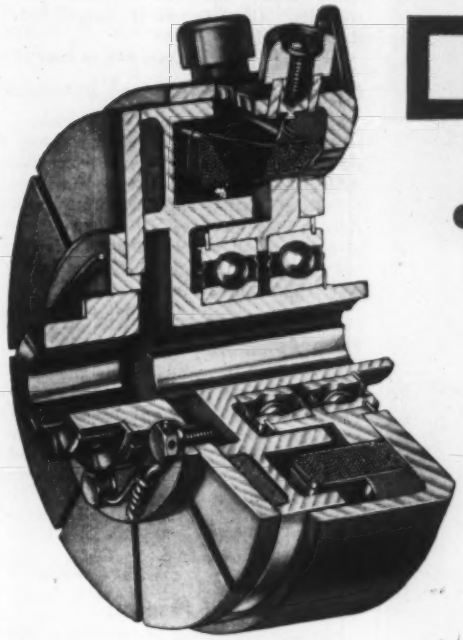
Wide variety of molded and disc type packing materials available for use in DS Series swivel joints adapt them for various services, including steam, chemicals, gases, and solvents. Specifications of the available styles are given. 4 pages. Chiksan Co., Brea, Calif. L

Circle 641 on Page 19

New—Small Sizes!

EATON DYNA-TORQ

MAGNETIC-FRICTION CLUTCHES and BRAKES



STATIONARY-FIELD, BEARING-MOUNTED DYNA-TORQ CLUTCH

Now Available in a Full Line from 1¾" to 15" Diameter

Eaton Dyna-torQ Magnetic-Friction Clutches and Brakes provide a simple, accurate, responsive method of controlling power and motion in today's complex production and processing machines.

The new smaller sizes and new design types of Dyna-torQ Stationary-Field Clutches and Brakes enable Eaton to offer a well rounded line, including flange-mounted and bearing-mounted clutches, and replaceable-face brakes. Unique features of design and construction result in worthwhile maintenance cost savings. Dyna-torQ units, easily and quickly installed on new machines or existing plant equipment, deliver many highly desirable advantages.

Dyna-torQ Magnetic-Friction Equipment Offers these Important Advantages:

- ★ Accurate power control
- ★ Dependable motion control
- ★ Rapid response
- ★ Easy "built-in" installation
- ★ Low maintenance costs
- ★ Compact plug-in type controls—may be remotely mounted
- ★ Inter-changeability of parts

Send for this new illustrated bulletin giving complete description and specifications covering Dyna-torQ Stationary-Field Clutches and Replaceable-Face Brakes.

EATON

Dyna-torQ Equipment is Available through Dynamatic Distributors in all Leading Cities

EATON DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

I'm being courted again...

You'd have thought Herbert actually had to handle those dirty old gears himself the way he'd come home cursing and mumbling about "rejects" and "added costs". But this is the third night this week he's taken me out for dinner! I'd certainly like to meet that CINCINNATI person!

Whether it's custom gears or custom gear boxes, you'll be pleased with CINCINNATI quality, price and delivery. Shaved gears to 39" diameter, tooth grinding capacity to 25". Write for brochure.

CINTI®

THE CINCINNATI GEAR CO.

Wooster Pike and Mariemont Ave. Cincinnati 27, Ohio
Custom Gear Makers Since 1907

GEARS, good gears only

Circle 496 on Page 19

HELPFUL LITERATURE

Cable Assemblies

Cable assemblies supplied in lengths as desired are offered in 34 standard types with common connector and molded terminal ends. They are described along with special and coaxial types in illustrated Catalog CA-12-58. Corona levels are given. 12 pages. H. H. Buggie, Inc., Box 817, Toledo 1, Ohio. G

Circle 642 on Page 19

Casters & Wheels

Swivel and rigid casters with Moldon rubber, molded plastic, semisteel, composition rubber, forged steel, and pneumatic rubber tired wheels are described in illustrated Catalog 130. Accessories are listed. Also covered are over 500 different sizes or variations of wheels. 16 pages. Hamilton Caster & Mfg. Co., 1700 Dixie Highway, Hamilton, Ohio. G

Circle 643 on Page 19

Hose Assemblies

Types of hose available for use with Krimp-Lok hose assemblies with permanently attached ends are shown and their specs are given in Catalog 4501. They are suited for many types of fluids and are tested up to 7500 psi. Available ends and adapters for the hose assemblies are shown. 4 pages. Parker-Hannifin Corp., Parker Fittings & Hose Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 644 on Page 19

Aluminum Mill Products

General information, characteristics, and typical properties of an extensive line of aluminum mill products are offered in an illustrated booklet. Covered are sheet, plate, foil, rod, bar, wire, extrusions, tubing, forgings, roofing and siding, ShadeScreen, process and other types of pipe and tubing, portable cords, bus conductor, welding cable, and other products. 24 pages. Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11, Ill. J

Circle 645 on Page 19

Stud Welding

Three available bulletins describe stud welding, the Mark XI stud welding gun, and a mobile battery power unit for stud welding, respectively. The first piece explains the stud welding process and its field of application. The remaining two provide specifications, and installation and maintenance instructions. 8, 4, and 4 pages, respectively. KSM Products Inc., Merchantville 8, N. J. E

Circle 646 on Page 19

Teflon Cylinders & Tubing

Stock List C-1 for Teflon hollow cylinders, tubing, and rod covers 1087 standard sizes for machining purposes. It also presents machining and general information on Teflon. Listing covers gaskets, lantern rings, piston rings, valve discs, packings, seat rings, sleeve bearings, adapters, shaft seal rings, back-ups, washers, and O-rings. Halogen Insulator & Seal Corp., 9960 Pacific Ave., Franklin Park, Ill. J

Circle 647 on Page 19

Tool & Die Steel

Technical data on machining, heat treatment, and mechanical and fatigue properties of Lo-Air tool steel are contained in illustrated Brochure TS-101. Applications are given and stock sizes listed for the low temperature air hardening steel. 12 pages. Universal-Cyclops Steel Corp., Bridgeville, Pa. F

Circle 648 on Page 19

Industrial Fasteners

Condensed bulletin describes a complete line of standard industrial fasteners, including socket screw products, pressure plugs, lock nuts, spring pins, dowel pins, and steel collars. Basic data on types, sizes, threads, and plating are included. 8 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa. C

Circle 649 on Page 19

Thermal Insulation

Characteristics and applications of Dicalite diatomite mineral fillers for thermal insulation are presented in Technical Bulletin E41. Its uses as admixtures for concrete, cement, and stucco and in asphalt compositions are covered. 12 pages. Great Lakes Carbon Co., Mining & Mineral Products Div., 612 S. Flower St., Los Angeles 17, Calif. L

Circle 650 on Page 19

Fittings & Flanges

Specifications of carbon, ferritic alloy, and stainless steel welding fittings and forged steel flanges are given for 1-in. nominal pipe size in Technical Bulletin FDC-254. 4 pages. Babcock & Wilcox Co., Tubular Products Div., Milwaukee 46, Wis. K

Circle 651 on Page 19

Printed Circuit Connectors

Specs outline dimensions, and general information on right angle pin and socket connectors for printed circuit applications appear in brochure. These miniature connectors are available in various contact sizes and molding compounds. 6 pages. Dejur-Amsco Corp., Electronic Sales Div., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 652 on Page 19

Alloy Steel Castings

The 1959 Reference Chart tabulates mechanical properties, analyses, specification designations, and heat treatments of carbon, low alloy, and stainless steel castings. General applications are provided as well. 6 pages. Lebanon Steel Foundry, Lebanon, Pa. E

Circle 653 on Page 19

Blowers & Exhausters

Three-lobe rotary blowers and exhausters for moving air or gas without contaminations are featured in Bulletin 581-R1. Single stage units are rated to 14 psi; multistage units, to 70 psi. They are capable of vacuums to 15 in. of mercury and capacities from 50 to 4000 cfm. 6 pages. M-D Blowers, Inc., Racine, Wis. K

Circle 654 on Page 19

Circle 497 on Page 19→

NEW

This is the ~~old~~ grind at

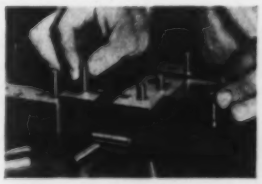
ALLEN

A quarter of a million square feet of space in the great new Allen plant is devoted to precision fasteners – and much of it houses batteries of the latest, high-speed automatic centerless grinding equipment. Here you see a close-up of the grinding section set up to produce dowel pins at the rate of one a second per machine.

Allen's vast new facilities assure constant standards of uniformity, accuracy, strength and fit, many of which are duplicated nowhere else. Now there's more reason than ever to make Allen *your* Buy-Word for socket screws, keys, pipe plugs and dowel pins.

Speaking of dowel pins – specify *Allen* for great strength where you need it most. Made of Allenoy steel, they're surface hardened to 62-64 Rockwell C. Core hardness 47-53. Case depth .010" to .020". Shear strength from 160,000 to 180,000 psi. Precision-ground to ±.0001", with a mirror finish of 6 RMS max.

In stock at your Allen Distributor . . . in dias. from ⅛" thru 1" . . . lengths from ⅜" thru 6". Also in two standard oversizes – .0002" for press fit, .001" for repairs. For more details, ask your local Distributor, or write directly to the Allen Manufacturing Company, Hartford 1, Conn.



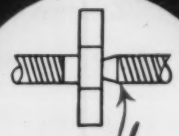
ALLEN HEAD HEX-SOCKET SCREWS

WHY

Product Improvement Means Profit Improvement For You

Look here

at the ways you can improve your profit with SCREWSTICK. The problem of handling, positioning, and dropping loose screws is eliminated. Joined in stick form, SCREWSTICK loads easily, drives automatically . . . as simply as the power driver is positioned by operator.



Look here

where driving torque is constantly controlled. The unique method of joining the screws in stick form assures exactly the same amount of torque with every screw applied. Send for free sample, application, specifications.

Profit Improvement Program

Buy here

The biggest News in Fasteners come from

American
SCREW COMPANY
WILLIMANTIC, CONN.
Chicago, Ill.
Detroit, Mich.

Circle 498 on Page 19

HELPFUL LITERATURE

Precision Castings

Plaster mold process for production of precision castings of brass, bronze, manganese bronze, aluminum, and other metals is described and illustrated in brochure. Engineering specifications and characteristics are given and case histories of design application are presented. 12 pages. Atlantic Casting & Engineering Corp., 810 Bloomfield Ave., Clifton, N. J. D

Circle 655 on Page 19

Carbon-Graphite

KaraK carbon-graphite for electrical, mechanical, thermal, and chemical applications is described as to characteristics, applications, designing advantages, and its mechanical strength, hardness, and metal impregnation qualities in Form 1164A. 8 pages. Ohio Carbon Co., 12508 Berea Rd., Cleveland 11, Ohio. G

Circle 656 on Page 19

Sheet Metal Fabrication

Designing, engineering, and manufacturing facilities, as well as typical products of this company are pictured in brochure. Supplementary bulletins from a subsidiary firm are offered on Gleason automatic take-up reels for electric cables and cords. 12 pages. Maysteel Products Inc., 800 Horicon St., Mayville, Wis. K

Circle 657 on Page 19

High Voltage Controls

Illustrated Booklet EN-162 entitled "High Voltage Control" discusses the features and individual characteristics of full and reduced voltage types of high voltage controls for squirrel-cage, synchronous, and wound-rotor motors. Ratings and design information are included. 16 pages. Cutler-Hammer Inc., 328 N. 12th St., Milwaukee 1, Wis. K

Circle 658 on Page 19

Rigid Plastic Fans

Centrifugal fans made of corrosionproof rigid plastic in 10½ to 35-in. single types and 12 to 48-in. twin-flow types are covered in Bulletins 9-20 and 9-21. Performance and application data are included. 14 and 4 pages. Atlas Mineral Products Co., Mertztown, Pa. E

Circle 659 on Page 19

Corrosion Resistant Alloys

Charts and graphs, as well as engineering data in booklet F-30131, serve to explain the corrosion resistance of Hastelloy, Haynes No. 25, and Multimet alloys. Various corrosives are listed alphabetically from acetaldehyde to zinc sulphate. 40 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 660 on Page 19

Tubing

Data Chart Sec. B, No. 3 contains extensive engineering and property data on free-cutting, carbon, and alloy steel tubing. Surface cutting speeds, chucking procedures, and method for calculating size to machine to finished dimensions are covered. 2 pages. Peter A. Frasse & Co., 17 Grand St., New York 13, N. Y. D

Circle 661 on Page 19

ACCEPT NO SUBSTITUTE

MEEHANITE CASTINGS ARE MADE ONLY BY MEEHANITE FOUNDRIES

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Blackmer Pump Co., Grand Rapids, Mich.
E. W. Bliss Co., Canton and Toledo, Ohio and Hastings, Mich.
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Pattern & Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co. Florence, N. J.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
The Hamilton Foundry & Machine Co., Hamilton, Ohio
Hardinge Company, Inc., New York, N. Y.
Hardinge Manufacturing Co., York, Pa.
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Koehring Co., Milwaukee, Wis.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

WRITE FOR YOUR FREE SINGLE COPY

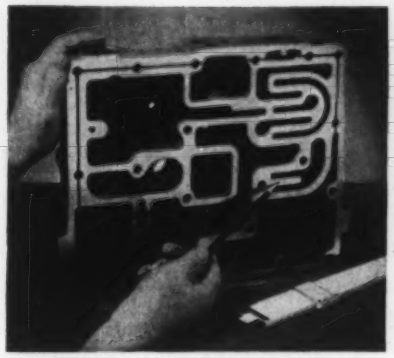
Bulletin 37-A: "Proof That Meehanite Bridges The Gap Between Cast Iron and Steel"

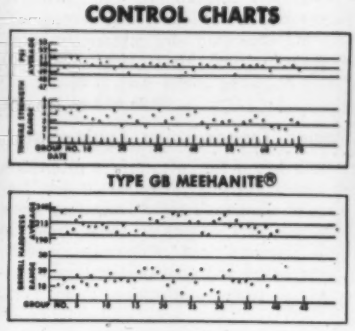
Write today to Meehanite Metal Corporation, Department 4D, 714 North Avenue, New Rochelle, New York.

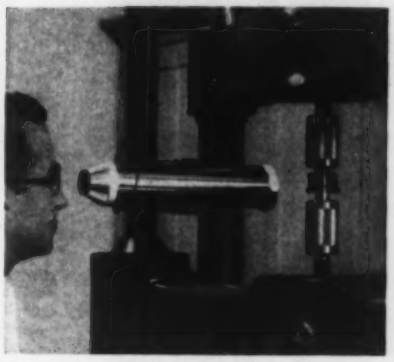
MEEHANITE®

Circle 499 on Page 19

6 REASONS WHY DESIGN ENGINEERS SPECIFY MEEHANITE CASTINGS







1. CASTING SOUNDNESS

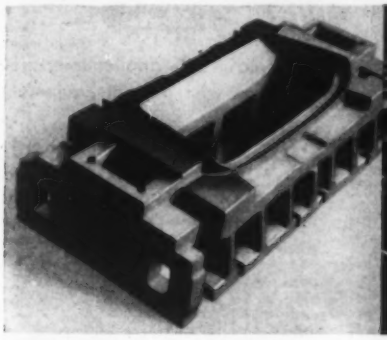
Of all casting properties this is the most important and is the BIG reason engineers specify Meehanite metal. They know from experience that Meehanite castings possess uniform strength and solidity through all sections, regardless of complexity of design or size. This assurance of casting soundness permits them to design with confidence.

2. FOUNDRY CONTROL

The reliability of castings is measured not by the maximum tensile strength value a foundry can supply in a single casting, but by how consistent the strength values are maintained. Meehanite foundry technique assures delivery of castings that have uniform high strength properties from one to a thousand. This control is vital to the engineer.

3. ENGINEERING PROPERTIES

There are 26 types of Meehanite metal. Each has a distinctive combination of properties which include high elasticity, strength and toughness, excellent impact strength, good damping capacity and superior wear resistance. This makes it easy for the engineer to select the type best suited to his conditions of service.



4. DIMENSIONAL STABILITY

Meehanite metal has found wide favor with design engineers because it exhibits an unusually high degree of dimensional stability in the "as cast" and also in the hardened condition. The ability to cast to close tolerances provides engineers with greater freedom in design and contributes directly to reductions in weight and machining costs.

5. LOW MACHINING COSTS

Engineers striving to cut costs as well as metal, turn to Meehanite®. The uniform structure of Meehanite® permits high speeds and feeds to be used with safety. Freedom from white edges and hard spots increases tool life. Meehanite metal shows a higher strength to machinability ratio than steels or unalloyed irons of equal strength and takes a high polish.

6. OUTSTANDING PERFORMANCE

Meehanite metal is saving Industry thousands of dollars each year in reducing the final cost of the component and increasing service life. A typical example is illustrated. In this application Meehanite metal Tooth Caps for heavy-duty land clearing rakes provide long wear life without failure under severe impact conditions.

MEEHANITE BRIDGES THE GAP BETWEEN CAST IRON AND STEEL®

MEEHANITE METAL

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

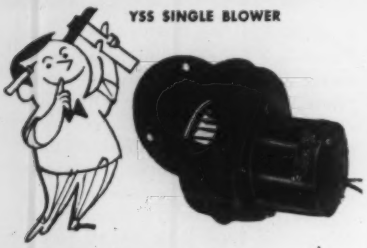
Circle 499 on Page 19

put HEINZE in your designs

YSD DOUBLE BLOWER

YS BLOWERS

YSS SINGLE BLOWER



MINIMIZE AIR NOISE

ASSURE LONG BEARING LIFE

Large (3⅝ in.) balanced air rotors, powered by a slow-speed 4 pole shaded pole induction motor, assure quiet operation and long bearing life. Blowers are enclosed in durable metal housing. YSS Single Blower delivers 50 cfm at 1650 rpm; YSD Double Blower delivers 100 cfm. Standard units operate on 115V, AC, 60 cycle. Other voltages and frequencies are available.

Applications include photographic dark rooms; laboratories; cooling of electronic tubes; kitchens; refrigeration and air conditioning units; vending machines; and similar uses.

Send coupon for technical data on the complete line of Heinze Sub-Fractional Horsepower Motors and Blowers.

HEINZE ELECTRIC COMPANY
685 Lawrence St., Lowell, Mass.
Sub-Fractional Horsepower Motors and Blowers

Heinze Electric Company, Dep't D
685 Lawrence St., Lowell, Mass.

Please send me technical literature and price information on Heinze Motors and Blowers.

Name & Title_____

Company_____

Street & No._____

City & State_____

Circle 500 on Page 19

HELPFUL LITERATURE

Flexible Metal Hose

The best ways to overcome flexing and vibration problems in diesel pipeline connections are discussed in Data Sheet 552 on Allflex flexible metal hose. Typical installations diagrammed are 90-degree permanent bends, lateral and vertical offset, and expansion and contraction types. 4 pages. Allied Metal Hose Co., 3753 Ninth St., Long Island City 1, N. Y. D

Circle 662 on Page 19

Power Transmission Equipment

Bulletin on line of power transmission equipment briefly describes major features of company's speed reduction, screw conveyor, and adjustable speed drives in both standard and wide-range models; motor bases; and conveyor and split pulleys. 4 pages. American Pulley Co., 4200 Wissahickon Ave., Philadelphia 29, Pa. E

Circle 663 on Page 19

Piston Seals

Adapted for use as a compact seal for pneumatic and low-pressure hydraulic cylinder pistons, Hercules Multi-Purpose Seals are described in illustrated bulletin. They are available for bores from 1½ to 10 in. and are made of synthetic rubber or phenolic materials. 4 pages. Hercules Packing Corp., 327 Washington St., Buffalo 3, N. Y. N

Circle 664 on Page 19

Insulating Plastics

Diall line of diallyl phthalate plastic molding materials is described in illustrated brochure. Insulating qualities and dimension stability under severe environmental conditions for Dacron, asbestos, glass, and Orlon-filled types are outlined. 12 pages. Mesa Plastics Co., 11751 Mississippi Ave., Los Angeles 25, Calif. L

Circle 665 on Page 19

Welded Steel Tubing

Size, weight, and use data on hot and cold rolled mechanical tubing are content of illustrated folder. Predipped and hot dipped galvanized types are offered in 3/8 to 3-in. OD sizes. 4 pages. Wheatland Tube Co., Bankers Securities Bldg., Philadelphia 7, Pa. E

Circle 666 on Page 19

Fasteners & Tools

Details of Hi-Shear rivets and Hi-Torque bolts for aircraft, missile, and related industry use are presented in illustrated catalog. Also covered are guns, tools, and accessories which facilitate installing these fasteners. Many design considerations are discussed. 36 pages. Hi-Shear Rivet Tool Co., 2600 W. 247th St., Torrance, Calif. L

Circle 667 on Page 19

Rotary Pumps

How Deming general-purpose, internal gear, rotary pumps work and are constructed is discussed in Bulletin 1535. Units are made in capacities up to 450 gpm and feature only two moving parts. 4 pages. Deming Co., Salem, Ohio. G

Circle 668 on Page 19

Some Reasons Why

DURA MECHANICAL SEAL

is the Best to Buy

DURA SEAL

is backed by 25 years of experience in the mechanical sealing field.

DURA SEAL

means successful sealing of corrosive, volatile or abrasive conditions.

DURA SEAL

meets the widest range of pressures, temperatures and liquids.

DURA SEAL

is easy to install—application can be made on your present equipment.

DURA SEAL

parts are interchangeable, providing economical operation on multiple applications.

DURA SEAL

is repairable—replacement of worn parts restores service and protects your investment.

DURA SEAL

is represented by a national network of Sales & Service Offices.

For information on types of Dura Seals to meet your sealing needs, write for copy of Catalog No. 480MD

The PERFECT SEAL

DURAMETALLIC CORPORATION
KALAMAZOO, MICHIGAN

Circle 501 on Page 19

Miniature Directional Signal. A foraging bee brings home one drop of nectar. His fellow workers sniff it like bloodhounds, and from the scent know just where to go for more. This tiny droplet is nature's miracle for keeping bees on the beam.

Miniature Selector Switch. Missiles stay on course when controlled by complex selector switch. Two MPB bearings on its shaft make frictional torque practically negligible, keep total weight down to .42 ounce. It's a man-miracle in miniaturization.

Man With Miracles. This is Hank Eckert, one of MPB's Sales Engineers. He helped the selector switch people find exactly the right type of MPB radial retainer bearing to hold friction to a minimum, give dependable service and assure operating precision.

Designers' dream world Miracles in Miniaturization

BEARING ACTUAL SIZE

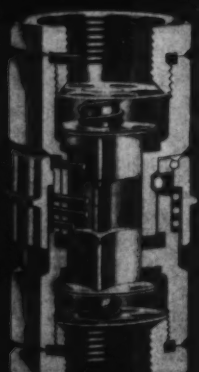
New Miracles. Today's industrial scientists are pioneering a whole new world of man-made miniaturization. With MPB miniature bearings and experience it is a wide, wide world on a tiny scale. For in miniaturization, bearings are one of the most critical considerations.

MPB makes miniature bearings ⅛" O.D. *down* (specials on request). In stock—over 500 types and sizes. Consult MPB when you are embarking on a miniaturization problem and/or write for new MPB catalog. **Miniature Precision Bearings, Inc.,** 102 Precision Park, Keene, N. H.

MPB

Helps you perform miracles in miniaturization

Circle 502 on Page 19



Provided with valves to give two way or one way automatic line shut off

Built to handle high pressure in hydraulic and air systems

Snap-Tite couplings stop the flow instantly"

Snap-Tite provides instant shut-off wherever fluid coupling is needed.

Snap-Tite couplings connect and disconnect quickly and fully—they automatically open line flow when connected; positively seal your line when disconnected—with no "ifs", no chance for human error.

Snap-Tite couplings are available in sizes from ¼" to 10" ID in all machinable metals. For more information, write for Snap-Tite catalog and, if you wish, describe your problem. Your local Snap-Tite representative will be glad to advise you.

SNAP-TITE COUPLINGS CAN HANDLE ALMOST ANYTHING THAT FLOWS

★Snap-Tite

ST-59-01

SNAP-TITE, INC. • UNION CITY 11, PA.

Adhesives, Coatings, Sealers

Design concepts, typical applications, and general characteristics of adhesives, coatings, and sealers are content of illustrated bulletin. Pictures show uses of these materials, and text explains properties and procedures. 12 pages. Minnesota Mining & Mfg. Co., Adhesives & Coatings Div., 900 Bush Ave., St. Paul 6, Minn. J

Circle 669 on Page 19

Turbine-Generators

Turbine-generators from 5000 to 100,000 kw for industrial and electric utility applications are subject of Booklet B-7373. It is divided into turbine and generator sections, the former being arranged for reference relating to condensing and noncondensing turbines, blading, shrink fit discs, steam chest, steam seals, nozzles, bearings, and rotors. 40 pages. Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa. F

Circle 670 on Page 19

Alloy Wire Cloth

"Which Inco Nickel Alloy Can Solve Your Wire Cloth Problem?" is a guide for engineers and designers of equipment which uses wire cloth for filters, dipping baskets, core-support structures, and other applications. Wire cloth and knitted mesh in various weaves and sizes are made of A-nickel, Monel, Inconel, and Incoloy. 16 pages. International Nickel Co., 67 Wall St., New York 5, N. Y. C

Circle 671 on Page 19

Ball Screwjack Assemblies

Kidde ball screwjack assemblies for converting linear motion to rotary or rotary motion to linear are offered with load carrying capacities to 40,000 lb. They can be supplied with shaft thread lengths to 69.75 in. and with up to 4-in. diameter shafts. Complete mechanical and design information is given in Bulletin A-22. 4 pages. Walter Kidde & Co., Aviation Div., Belleville 9, N. J. D

Circle 672 on Page 19

Power Supplies

Functions of an autotransformer and filtered rectifier circuit are combined in the RC-Nobatron Ranger power supplies to provide continuously variable dc and ac power. Output is 0-130 v ac at 7.5 or 15 amp, 0-36 v dc at 15 or 30 amp, or 0-150 v dc at 4 or 7.5 amp. Specifications are given on data sheet. 2 pages. Sorensen & Co., Richards Ave., South Norwalk, Conn. B

Circle 673 on Page 19

Automatic Air Filter

Performance characteristics of the new Model B Roll-O-Matic renewable-media air filter are presented in Bulletin 248-C. "Miracle" media used in this automatic filter consists of a 65-ft long roll of plastic reinforced glass fiber having a nominal thickness of 2 in. Media is fed automatically over filter area. 12 pages. American Air Filter Co., 215 Central Ave., Louisville 6, Ky. G

Circle 674 on Page 19

You'll find them better for pressure if they're

SHENANGO CENTRIFUGAL CASTINGS

WHATEVER the inside or outside pressures, Shenango centrifugal castings are better able to withstand them without failure.

Parts cast by the Shenango centrifugal process are much tougher because their finer, *pressure-dense* grain avoids stress concentrations while providing greater strength, better elongation and freedom from such costly defects as sand inclusions, blowholes and such.

Whether you need rings, rolls, sleeves, liners, bushings, bearings, mandrels or *any* annular or symmetrical part . . . ferrous or non-ferrous . . . in whatever shape, size or dimension to meet your requirements . . . Shenango can do the job. And do the job *better!*

For informative bulletins on the answers to your tough problems, it will pay you to write now to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, O.

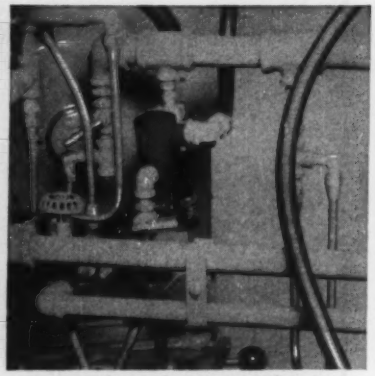
SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

Circle 504 on Page 19

Why Skinner V5 solenoid valves are solving so many control problems

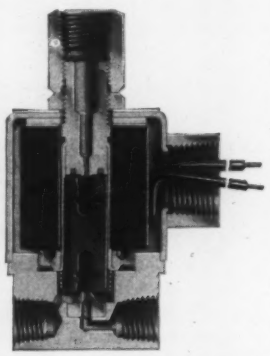
Application: The Leland-Gifford nine-unit hydraulic drilling machine used for drilling crankshafts uses two-way Skinner V5 valves to control the flow of coolant at each operating station of the fixture.



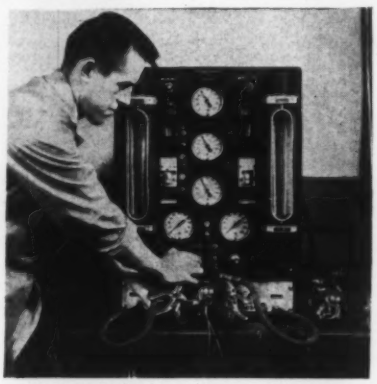
Automatic coolant operation: The Skinner V5 2-way normally closed valves are wired so that at the start of the drilling operation the valves are energized causing coolant to flow before the drill starts its drilling pass. When the cycle is complete the drill retracts, the valves are de-energized and the flow of coolant is halted.

Simple maintenance and repair: The design of Skinner V5 valves permits hand disassembly for cleaning without removal of the valve from the line. Coils, housings, plungers, sleeves are interchangeable and easily replaced.

Skinner stainless steel V5 valves are offered in two- and three-way construction, normally open, normally closed, directional control, multi-directional, quick exhaust. Orifices: 1/32″ to 3/8″; NPT ports: 1/8″, 1/4″, and 3/8″; pressure ratings: to 3000 psi. Explosionproof models UL approved for both Class 1, Group D and Class 2, Groups F and G are available.



Engineered to highest UL standards: Body and internal parts of *frequently copied* V5 valve are stainless steel and, thus, corrosion-resistant. Durable, compressible inserts of soft synthetic materials insure bubbletight operation. Orifice seats have radius with well-rounded contact area and high finish for long insert life.



100% tested. Prior to shipment, every V5 valve is tested for both internal and external leakage under full pressure conditions with modern, sensitive detecting equipment. In these laboratory tests Skinner V5 valves regularly get over 20-million cycles without leakage. And these results are constantly proving out in service.

Skinner solenoid valves are distributed nationally.

For complete information, contact a Skinner Representative listed in the Yellow Pages or write us at Dept. 422

SKINNER ELECTRIC VALVES®

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION
NEW BRITAIN CONNECTICUT
105 EDGEWOOD AVENUE

Converter-Inverters

Data File 701 on Transidyne transistorized converter-inverters shows various case styles and lists features and specs of four basic series. These completely static devices convert ac or dc input voltages to ac and dc outputs of different voltage levels or frequencies. 4 pages. Spectrol Electronics Corp., 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 675 on Page 19

Forging Facilities

All phases of company's forging facilities, and a range of products are covered in well illustrated Brochure SB-1258. Characteristics and uses for some of the world's largest custom-die forgings made are listed. One section is devoted to forging problems and solutions. 24 pages. Park Drop Forge Co., E. 79th St. & Buck Ave., Cleveland 3, Ohio. G

Circle 676 on Page 19

Elastomer

Physical, chemical, thermal, and other properties of Disogrin polyurethane elastomer are explained with graphs, charts, tables, and text in bulletin "There's a Material Difference." Tips on how to obtain better design with this material are discussed. 24 pages. Disogrin Industries, Inc., 510 S. Fulton Ave., Mount Vernon, N. Y. D

Circle 677 on Page 19

Industrial Truck Batteries

Exide-Ironclad storage batteries for electric industrial trucks which boost the work capacity as much as 44 per cent are detailed in Bulletin 6230. How engineering advances have made this possible is explained. 8 pages. Electric Storage Battery Co., Exide Industrial Div., Rising Sun & Adams Avenues, Philadelphia 20, Pa. E

Circle 678 on Page 19

Aluminum Alloy

Design specifications, mechanical properties, and casting techniques for TENS-50 high strength aluminum casting alloy are contained in illustrated bulletin. 12 pages. Navan Products, Inc., International Airport, Los Angeles 45, Calif. L

Circle 679 on Page 19

Cartridge Type Heater

Technical data and prices on 3/8, 1/2, and 5/8 in. diameter Firerod cartridge type electric heaters are found in illustrated Bulletin 366. Offered for 28, 115, and 230 v, wattages range up to 4700 w. 6 pages. Watlow Electric Mfg. Co., 1376 Ferguson Ave., St. Louis 14, Mo. I

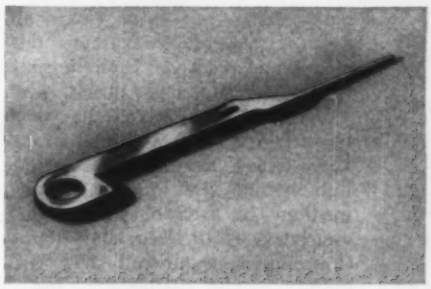
Circle 680 on Page 19

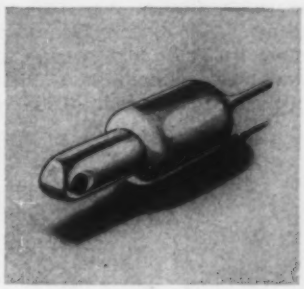
Brass Products

Weight, size and tolerance tables, specifications, and other technical data on Titan free-cutting brass, commercial bronze, nickel-silver, high silicon brass, manganese bronze, forging rods and shapes, brass wire, and Tru Shaft boat shafting are found in booklet "For Your Metal Money's Worth." 24 pages. Request on company letterhead from Titan Metal Mfg. Co., Bellefonte, Pa. G

NEWS
from Torrington on
SMALL PRECISION METAL PARTS

"Custom manufacture" need not be costly—at least, as practiced at Torrington's Specialties Division. Our engineers, experienced in a multitude of methods and operations, have a knack for fitting the most efficient techniques to any small metal part in question. And these methods are not necessarily the most obvious. The motto might well be, "Precision at any cost—so long as it's the *lowest* cost possible!"





Take the control pin and sensing pin we make for a leading business machine manufacturer. Diameter of the circular section must be held to .001". Other critical dimensions require as stringent tolerances. Torrington selected a combination of stamping and swaging operations as most economical and efficient. High accuracy is achieved without tool marks or stress concentration points. Parts are tempered to RC 52-54, and are accurate to required tolerance *without grinding* and have a better finish than grinding would produce!

Then there's the pin we make for an aircraft application. Made of 440C stainless—a difficult material to work—it is finished to 8 micro-inches, again without grinding. The three radii are held concentric to .006". After tempering to RC 52-60, the part is given a .0002 to .0004" hard chrome plate.

Part of the perfection of the finished unit is the quality of material used. Skilled metallurgists have access to the most modern laboratory equipment to make sure materials meet your drawing specifications. We maintain three separate heat-treating departments, each with equipment selected for specific types of parts or materials involved. Statistical quality control methods insure the quality of product you specify. For help with

your large quantity requirements of small precision metal parts, just circle our number on the reply card, call our area salesman, or write direct to:

The Torrington Company, Specialties Division, 626 Field Street, Torrington, Conn.

TORRINGTON SPECIAL METAL PARTS

Makers of Torrington Needle Bearings

Circle 506 on Page 19

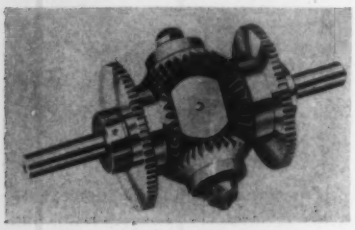
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Miniature Differentials

in 1/4, 3/16, and 1/8-in. shaft sizes

For use as speed controllers, or as sensing devices for mechanical comparison or error measurement, miniature differentials are also used as basic computing elements in many servo systems for addition or subtraction of two shaft movements. All models feature minimum backlash, high accuracy, and low breakaway torque. No. BP-301 has 1/4-in. shaft, 0.065 oz-in.



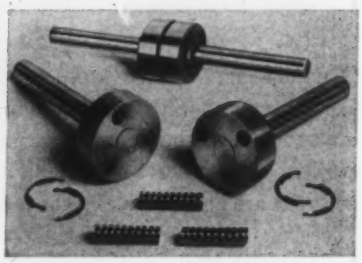
breakaway torque, maximum recommended torque of 150 oz-in., and maximum recommended speed of 1800 rpm. BP-310 has 3/16-in. shaft, 0.06 oz-in. breakaway torque, maximum recommended torque of 100 oz-in., and maximum recommended speed of 1800 rpm. No. BP-320 has 1/8 in. shaft, 0.06 oz-in. breakaway torque, 90 oz-in. maximum recommended torque, and maximum recommended speed of 1400 rpm. **Helipot Div., Beckman Instrument Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 681 on Page 19

Free-Aligning Coupling

uses no nuts or bolts

Design of new coupling has halves of coupling joined to transmit thrust through helical wire springs held in place by snap or split rings. Coupling operates in either direction of rotation and can be installed vertically without any



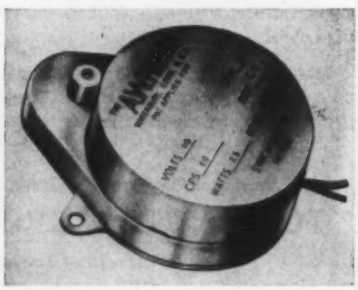
parts change. Unit is shock absorbing, permits maximum misalignment because it transmits torque without end thrust, even under load. Coupling has load factor of 7:1, and is available in any size. Three standard sizes include light (shaft size to 2 in. diam), medium (2 to 5-in. shaft diam), and heavy (5 to 12-in. shaft diam). Coupling is usually all steel, with aluminum also available for use in corrosive atmospheres. **Atomatic Mfg. Co.**, East Pittsburgh, Pa. F

Circle 682 on Page 19

Timing Motors

are only 7/8 in. thick

Series 22100 synchronous timing motors are available for 25, 50, or 60-cycle operation in five standard voltage ratings. Only 7/8 in. thick, motors are designed for applications where high performance, reliability, and immunity to rugged environments are required. Units meet all significant requirements of specification MIL-E-5272A. A nonmilitary version is available for high-



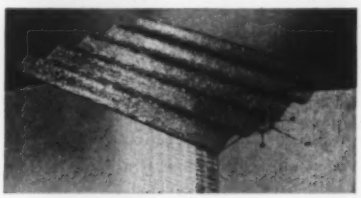
volume industrial and commercial applications. Over 125 standard output speeds from 300 rpm down to one revolution in 6 hr can be supplied with either standard or heavy-duty gear trains. **A. W. Haydon Co.**, 232 N. Elm St., Waterbury 20, Conn. B

Circle 683 on Page 19

Translucent Plastic Panels

have integral patterns and designs

Patterns in Patnel plastic panels are embedded in glass-fiber reinforced polyester resin during manufacture. Process adds compatible patterns in color combinations to the shatterproof, lightweight, and weather-resistant features of the plastic. In addition to standard patterns, practically any individual design, device, or commercial theme



can be incorporated in the plastic material. **Kemlite Corp.**, 101 N. Republic Ave., Joliet, Ill. J

Circle 684 on Page 19

Pushbutton Switch

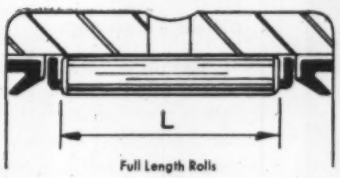
miniature unit has independent light circuit

No. 40-1 lighted pushbutton switch is a normally open, momentary-contact unit rated 1 amp, 115 v ac for minimum life of 500,000 operations. Light circuit incorporates an NE-2 neon bulb and is independent of switch circuit, permitting greater flexibility. Less than 1 1/4 in. behind-panel length, 3/8-32 threaded bushing, and 7/16 in. maximum

More Load Capacity! More Design Flexibility!

ORANGE SEALED *Cage Type* NEEDLE BEARINGS

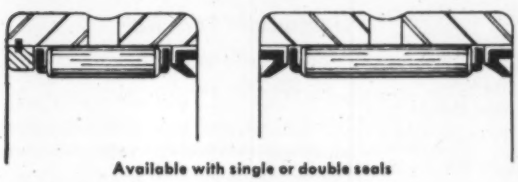
Longer Rolls—Higher Capacity



Full Length Rolls

Only Orange construction provides effective sealing without reducing roll length or load carrying capacity. Note the proportion of roll length to race, compared with other types. You get the full load capacity of Orange Cage Type Needle Bearings—plus the economy and efficiency of built-in Neoprene seals to keep dirt out and lubricant in.

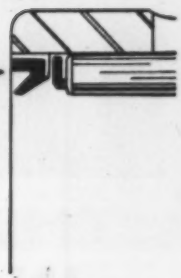
TWO Bearing Lengths for Design Flexibility



Available with single or double seals

Only Orange offers Sealed Cage Type Needle Bearings in TWO bearing lengths for each shaft diameter. Both bearing lengths have full-length rolls in proper proportion to race, providing maximum load-carrying capacity. Thus, you have greater flexibility in meeting load, space and design requirements. Other sealed needle bearings offer only one bearing length, with shorter rolls and less capacity.

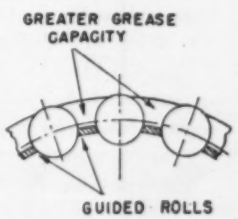
Effective Seal Design →



This provides positive exclusion of foreign matter, retains lubricant and acts as a vent to prevent displacement of seal if additional lubrication is added through holes provided in races.

—plus advantages of Orange Cage Design

The Orange cage design assures constant contact with entire length of roll periphery to provide the ultimate in guided rolls and resistance to skewing. Adequate space around rolls provides exceptional capacity for lubrication.



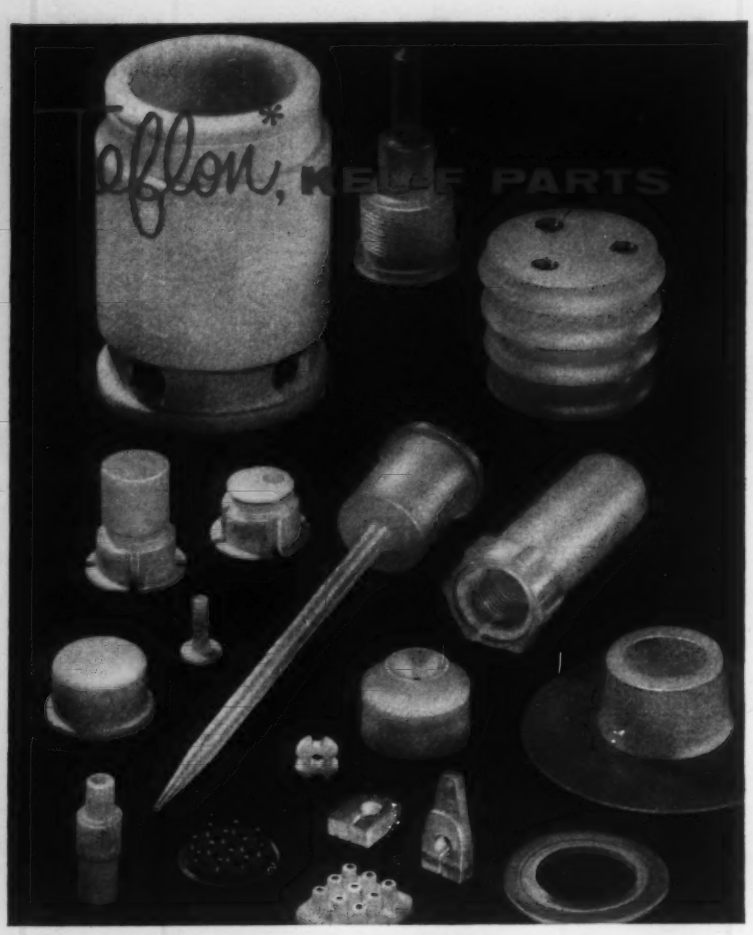
Stocked in popular sizes from ½" to 4" shaft diameters. Other sizes will be added as volume requirements are established.

Write for new, detailed brochure giving engineering data, construction, dimensions, etc.

ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers



THE *DIFFERENCE* IS IN THE MAKING

Good quality fluorocarbon parts require special processing techniques. This is why Garlock's United States Gasket Plastics Division is called upon so often to fabricate parts of fluorocarbon plastics. They have the personnel, the facilities, and unequalled experience in handling TEFLON and KEL-F. They specialize in precision molding and machining where close tolerances, intricate shapes, delicate wall sections, inserts, molding around metal, and threaded parts are involved.

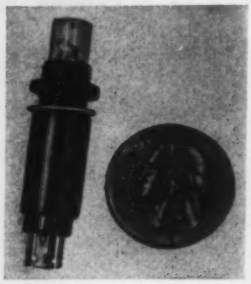
If you have a difficult fluorocarbon problem, why not send it to your local Garlock office for quotation? Guarantee yourself the best in parts, methods, and price.

United States Gasket *Plastics Division of* **GARLOCK**

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada, or write The Garlock Packing Company, Palmyra, New York.

*DuPont Trademark
†M.M.&M. Trademark

Circle 508 on Page 19



diam allow for minimum mounting space. Nut and housing area are anodized aluminum, and contacts are fine silver. Solder-type terminals are standard. **Grayhill Inc.**, 561 Hillgrove Ave., LaGrange, Ill. I

Circle 685 on Page 19

Encapsulating Resin

provides high moisture resistance

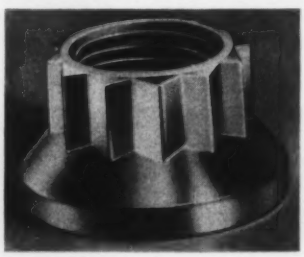
Fosterite SFR BT-3199 silicone-modified filled encapsulating resin is designed for use in treating electronic components that require high moisture resistance and flame retardance. It is recommended for treatment of components such as filament, power and plate transformers for communications, fire control, radar, and guided missiles. **Micarta Div., Benolite Plant, Westinghouse Electric Corp.**, Manor, Pa. F

Circle 686 on Page 19

Lightweight Lock Nut

has tensile strength of 220,000 psi

FN-22 lock nut combines exceptional strength-to-weight ratio with superior fatigue characteristics and high reusability. Designed primarily for aircraft, missile, and related use with bolts of 220,000-psi ultimate tensile strength, it also affords a favorable strength-weight



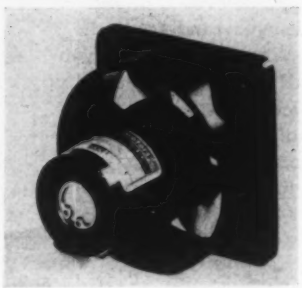
ratio when used with 180,000 or 160,000-psi bolts. Fatigue strength is developed through close tolerance on squareness (0.003 in.) between nut bearing face and threads. The cadmium-plated alloy-steel fastener, for use in temperatures to 550 F, meets requirements of specification MIL-N-25027. The redesigned nut is a 12-point external-wrenching type with lower over-all height, smaller over-all diam, and reduced across-flats dimension. It is available in sizes from ¼ through ½ in., with or without molybdenum-disulfide coating. **Standard Pressed Steel Co.**, Jenkintown, Pa. C

Circle 687 on Page 19

Miniature Fan

cools electronic equipment in restricted spaces

Model S2223-3 axial fan, using a 1-in. diam motor delivers 40 cfm at 16,500 rpm. It is suited for spot-cooling electronic equipment in restricted spaces. Unit operates from



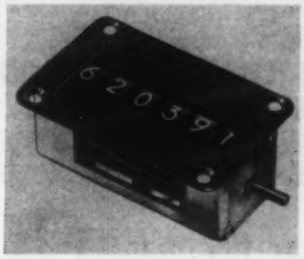
a 200-v, three-phase, 400-cycle source. It withstands ambient temperatures to 125 C with minimum life of 200 hr. Fan meets all requirements of MIL-E-5272. Dimensions of the unit are 2 in. maximum length, with square 2¼-in. mounting flange. **Air-Marine Motors Inc.**, 369 Bayview Ave., Amityville, N. Y. D

Circle 688 on Page 19

Mechanical Counter

uses planetary-gear drive to rotate numerals

Quick transfer of numbers is accomplished in PlanetGear counter by a nylon cam-and-roller compensating device which moves planetary gear. Unit uses a planetary-gear drive to rotate numerals rather than Geneva movement. Gears are always in mesh, eliminating possi-



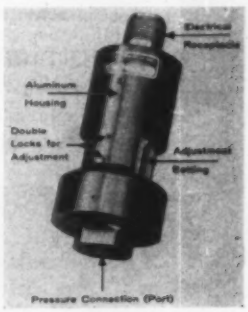
bility of skips or misses. There are no peak load points in operation of counter. Smooth action of planetary gears permits driving counting wheels at continuous high speeds of 1000 rpm or 10,000 counts per minute. Bearings, gears, cams, and rollers are nylon. Main shaft is centerless-ground, polished stainless steel. Large 5/16-in. numbers conform to military specification MIL-S-33558 (ASG). Counter shown is a six-digit, nonreset, nonreversing model. **Haydon Instrument Co.**, 165 W. Liberty St., Waterbury 20, Conn. B

Circle 689 on Page 19

Miniature Switch-Transducer

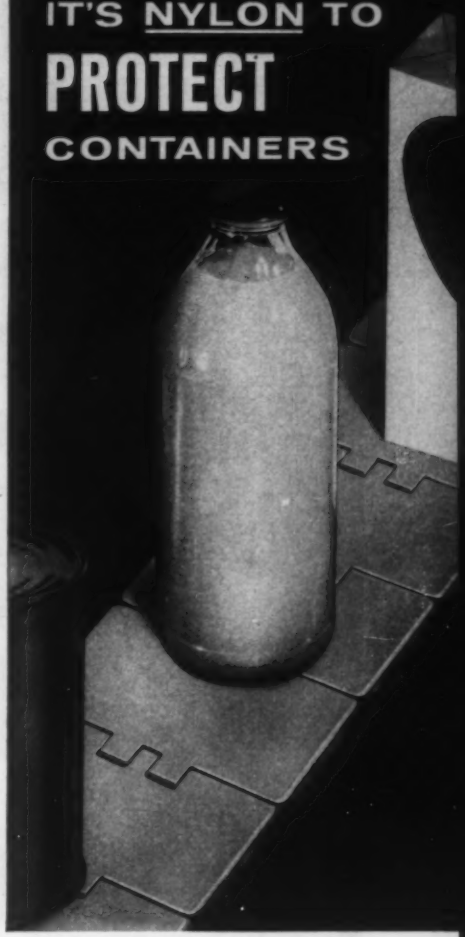
covers span from 0.5 to 4000 psi

Series 1500 pressure switch- transducer has applications in lubricating, pneumatic, hydraulic, fuel, chemical, and gas-pressure systems. Moving parts are contained in an aluminum housing, sealed at each end by O-rings. Assembly, which weighs only 6 oz, senses pressure level from 0.5 to 4000 psi by changing internal modular components. Eight switches cover complete pressure span. Exact calibration of each switch assembly is obtained by rotating external pressure-setting adjustment, which is then locked by two setscrews. Assembly re-



Another PLUS value...

IT'S NYLON TO PROTECT CONTAINERS



Rex Nylon TableTop Chain is easy on containers because *it operates without lubrication.* No lubricant stains to soil containers...no "wearing" metal-to-metal contact when handling cans!

Nylon TableTop is smooth in operation. It's quiet...easy to assemble... stays cleaner and is easy to clean. For complete information, mail the coupon.

REX®
NYLON TABLETOP®

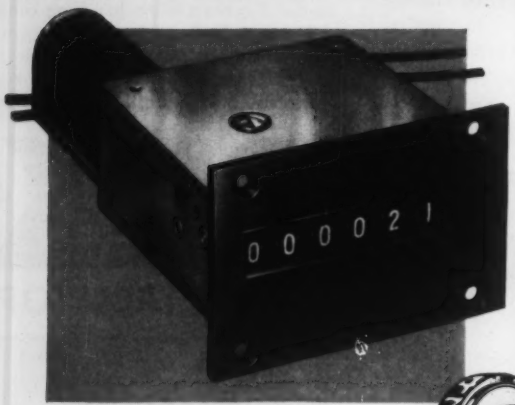
CHAIN Belt Company 108-A
4643 W. Greenfield Ave.
Milwaukee 1, Wisconsin
(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto)
☐ Send me my copy of Bulletin No. 5865.
☐ Have a Rex man call.
Name.....
Company.....
Address.....
City.....*Zone*.....*State*.....

Circle 509 on Page 19

How can you prove your guarantee unless your product can COUNT?

When customers come after you with claims concerning your product's performance, can you prove your position? You can, to everyone's satisfaction, if Veeder-Root Counters are built into your product as standard, integral parts. For then your customers have Facts-in-Figures on actual performance on the job, figures that settle arguments fairly and squarely . . . in fact, often prevent misunderstandings in the first place. What's more, when you build-in V-R Counters, you build up your product's sales appeal . . . as many manufacturers have found to their profit. So can you. Write and find out how.

You always "Know the score" when you count on Veeder-Root!



NEW Panel-Mounted, High Speed Electro-Magnetic Counter

Series 1591 Counters are ideal for DC applications requiring accuracy and long life at very high speeds. 4 or 6 figures. Instant pushbutton reset or remote electrical reset.

Electrical Contactor

Assures positive actuation of 1591 Counters. Drive by lever or forked coupling.

Everyone can Count on VR®

Veeder-Root Inc.

HARTFORD 2, CONNECTICUT

Hartford, Conn. • Greenville, S. C. • Altoona, Pa. • Chicago
New York • Los Angeles • San Francisco • Montreal
Offices and Agents in Principal Cities

Circle 510 on Page 19

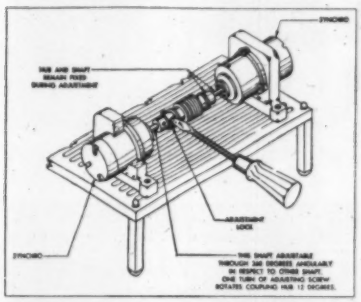
sists corrosive operating media. Optional mounting bracket provides vibration isolation up to 2000 cps and to 50 g. **Haydon Switch Inc.**, 536 S. Leonard St., Waterbury 20, Conn. B

Circle 690 on Page 19

Adjustable Couplings

permit continuous adjustment through 360 deg

Types T-9 and T-10 couplings provide precision rotational angular adjustment between two synchro rotors or other mechanisms requiring angular displacement. Coupling eliminates need for rotating a synchro in its mounting to zero in with companion synchro. Desired angular displacement between two synchros is obtained by rotating one synchro rotor in respect to other through adjustable coupling. Precision angular adjustment is possible, since one turn of coupling adjusting screw rotates one coupled shaft in respect to other through only 12 deg. Continuous rotational adjustment through 360 deg in either direction is provided. Unit can be adjusted with a screwdriver, and adjustment can be locked at any desired setting by a setscrew on adjustable side of coupling. Over-all length is 1.862 in., and diam is 51/64 in. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D



Circle 691 on Page 19

Miniature Speed Changer

is adjustable over 25:1 range

Series 2 adjustable-ratio unit has a black, all-aluminum anodized housing with long, easy-to-read scale. It is supplied with either servo or foot mounts. Foot mounts can be rotated 90 deg in either direction. Over-all length of housing

is 2⅝ in. Stainless-steel input and output shafts of 3/16 in. diam run in double, heavy-duty shielded ball bearings. Maximum horsepower output is 0.025, and maximum speed is 10,000 rpm. Unit is adjustable over 25:1 range from 1:5 up to 5:1 down. Torque output is 5 to 40 oz-in. depending on ratio setting. **Metron Instrument Co.**, 432 Lincoln St., Denver 3, Colo. K

Circle 692 on Page 19

Aluminum Conduit

with diameter from 1/2 through 6 in. in 10-ft lengths

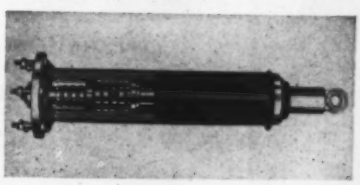
Rigid conduit, couplings, and 90-deg conduit elbows meet same size, shape, and tolerance requirements as those for steel conduit. Nominal diameter sizes for the aluminum conduit range from ½ through 6 in. in standard 10-ft lengths. Conduit is chemically coated inside, making wire pulling easier. It is one-third the weight of steel, nonrusting, resistant to corrosion, nonsparking, and nonmagnetic. **Kaiser Aluminum & Chemical Sales Inc.**, 919 N. Michigan Ave., Chicago 11, Ill. J

Circle 693 on Page 19

Ball Screwjacks

have low friction and negligible backlash

Screwjack assemblies perform linear and rotary motions calling for rapid reversal of heavy loads. Screwjack uses a screw and nut, each with a concave helical ball race. Within



Another PLUS value...

CONTROLLED
FOR HIGHER SPEEDS

With Rex Roller Chains you get highest fatigue strength for longest chain life ...ability to handle heavier loads and higher speeds because these chains have the *PLUS VALUE—pitch control!* Every chain part carries its full share of the working load...no unequal loadings to cause fatigue failures. Each link is accurate...pitch is precisely controlled. Result: no chain fatigue! To find out how pitch control helps you, mail the coupon.

REX®
ROLLER CHAINS

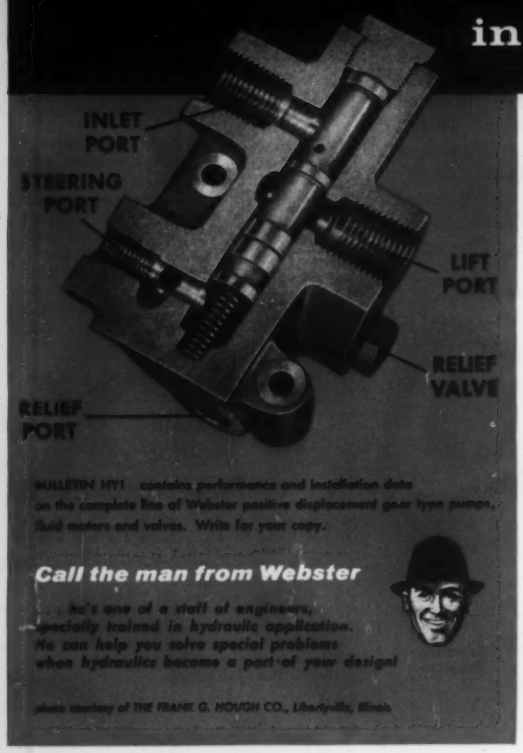
CHAIN Belt Company 415
4643 W. Greenfield Ave.
Milwaukee 1, Wis.
(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto, Ontario.)
☐ Send me my copy of Bulletin 5725.
☐ Have a Rex Man call.

Name.....
Company.....
Address.....
City.....*Zone*....*State*.....

Circle 511 on Page 19

DYNAMIC DIFFERENCE

in hydraulic performance



BULLETIN HY1 contains performance and installation data on the complete line of Webster positive displacement gear type pumps, fluid motors and valves. Write for your copy.

Call the man from Webster

. . . he's one of a staff of engineers, specially trained in hydraulic application. He can help you solve special problems when hydraulics become a part of your design!

photo courtesy of THE FRANK G. HOUGH CO., Libertyville, Illinois

Webster

HIGH CAPACITY FLOW DIVIDERS

Material moving magic! 20 cubic feet at a bite, this highly maneuverable front-end loader cuts big piles down to size — without missing a beat. Hydraulics play an important roll here — in power steering, in powering the bucket. But there's only *one* hydraulic pump. A Webster flow divider supplies *both* hydraulic circuits — and permits each to be operated *simultaneously* at different pressures from a *single pump!*

There are more advantages . . . Webster flow dividers operate at pressures up to 2000 psi, capacities to 60 gpm. They're small, compact to fit easily in tight quarters on mobile equipment. Adapt easily and economically to your product and the job.

When *you* plan hydraulics, plan on Webster . . . *for the dynamic difference that pays!*

OIL HYDRAULICS DIVISION

WEBSTER ELECTRIC

RACINE · WIS

our 50th year

franzen adv. H-115

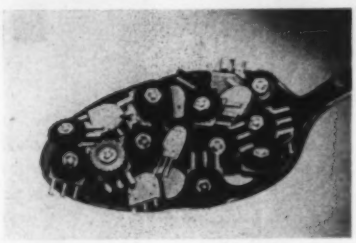
nut, length of race is filled with precision ball bearings which serve as medium of engagement between nut and screw. Nut has one or more ball circuits, with ball return paths spaced symmetrically around nut circumference so that each path covers nearly 360 deg. Design forms a closed circuit through which rolling balls recirculate continually. Recirculation takes place whenever screw and nut are rotated relative to one another. Units have low friction and negligible backlash. Load-carrying capacity is up to 40,000 lb. Service temperature is up to 900 F, and by using special metals, units can be designed for operation in temperatures to 1700 F with minimum lubrication. **Aviation Div., Walter Kidde & Co. Inc.**, Belleville, N. J. D

Circle 694 on Page 19

Variable Resistor

miniature unit is rated at 9.2 w

Measuring only 0.286 in. in diam and 0.11 in. in depth, Model 8 Radiohm is rated at 0.1 w and has component density of 188 per cu in. Unit is available in production quantities in resistance values



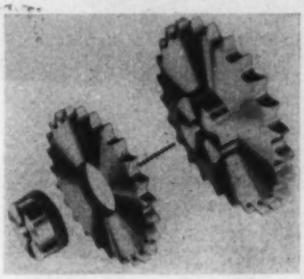
of 500 ohms to 10 megohms in a wide range of tapers. Miniature control has minimum rotational life of 25,000 cycles. **Centralab**, 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 695 on Page 19

Sprocket Assemblies

have interchangeable plates and hubs

Selecta-Bore finished-bore assemblies provide a complete line of over 600 possible pitch, teeth, and bore-size combinations. Bore sprocket requirements can be filled by assembling interchangeable plates and hubs. Each assembled sprocket is ready for installation, complete with



standard keyway and setscrew. **Whitney Chain Co.**, 237 Hamilton St., Hartford 2, Conn. B

Circle 696 on Page 19

Metallic Foil Flake

for decorative surface design

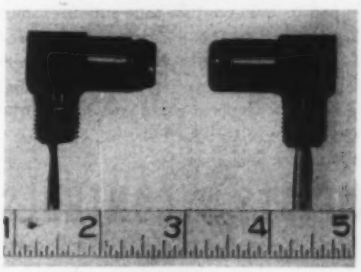
Metalflake consists of small bits of colored metallic foil produced in uniform sizes such as square, rectangle, round, star, oblong threads, and others. Used in custom laminations and coatings, they provide decorative effects on textiles, paper, plastics, leather, and other material surfaces. Colors are fast to light and bleeding, and foil has maximum abrasion resistance. Flake of 0.0008-in. thickness is available in sizes from 1/64 to 1/4 in. in squares and rectangles, and to 3/16 in. in stars and random-cut shapes. Standard colors are gold, silver, red, green, blue, and fuchsia, and combinations of these. Method of application depends upon material to which foil is to be applied. **Dobeckmun Co. Div., Dow Chemical Co.**, 3301 Monroe Ave., Cleveland 1, Ohio. G

Circle 697 on Page 19

Pickup Units

for counting, positioning, sequencing, and monitoring

Miniature pickup units operate a relay when a direct light beam is



Another PLUS value...

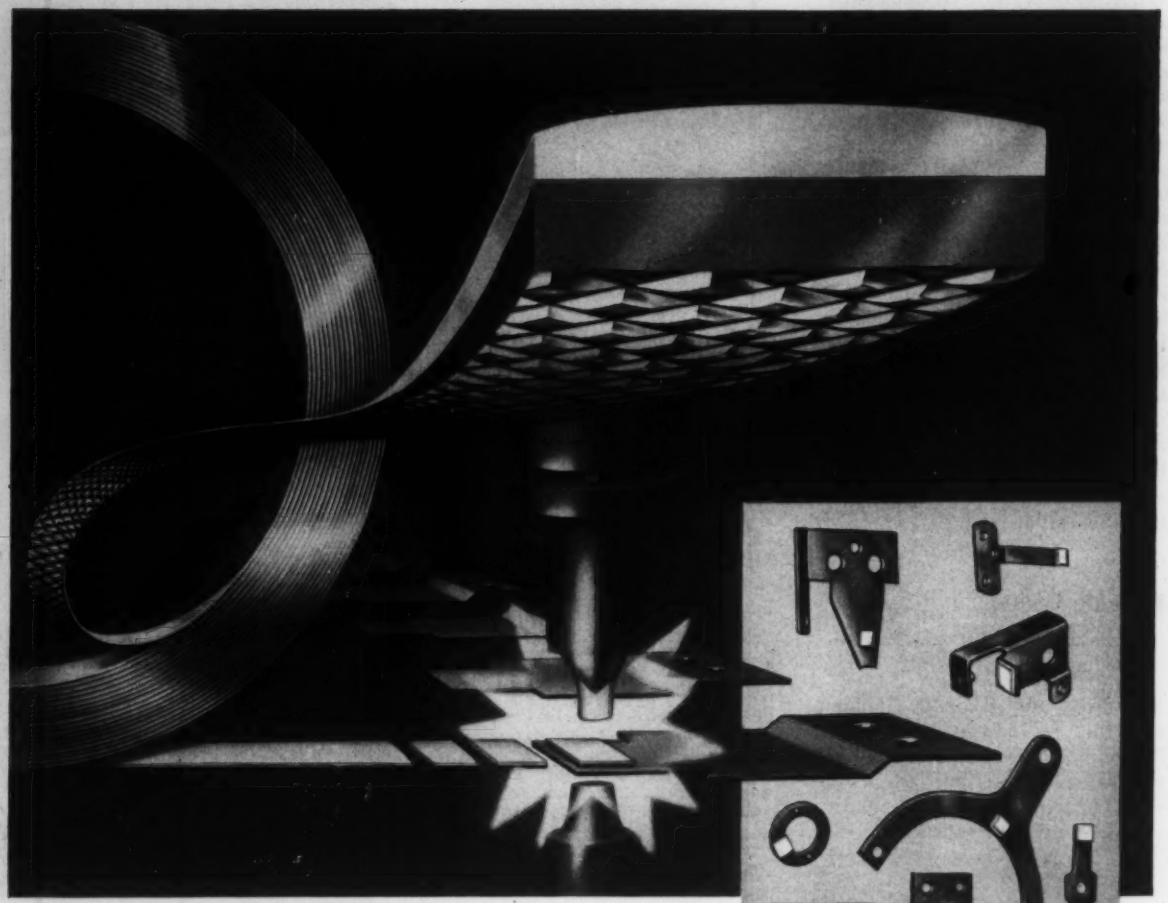
PREMIUM CHAIN
...NO EXTRA COST

Rex Roller Chains are designed to give you longest possible wear life. For example, as shown above, all standard roller chains have oil holes in the bushings to assure easy penetration of life-adding lubricant to the important pin-bushing contact area...a vital factor, particularly on high-speed drives. You get many more cycles of wear life...a PLUS VALUE premium chain at no extra cost. For complete information, mail the coupon.

REX®
ROLLER CHAINS

CHAIN Belt Company 414
4643 W. Greenfield Ave.
Milwaukee 1, Wis.
(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto, Ontario.)
☐ Send me my copy of Bulletin 5725.
☐ Have a Rex Man call.
Name.....
Company.....
Address.....
City.....Zone....State.....

Circle 513 on Page 19



Now with General Plate Electrical Contact Tape... You Can

SAVE UP TO 40%

On Contact Cost

In addition . . .
Contact Tape permits:

- **Broader latitude in contact assembly design**
- **Smaller contacts for same electrical loads**
- **Weight-saving**
- **Simpler material handling**

General Plate Electrical Contact Tape can be applied to any large-volume contact design, permitting the automatic assembly of two or more parts in a single operation.

Tape contacts are easily attached by spot welding methods. They are self-aligning . . . allow broader assembly tolerances. Because of this, tape contacts reduce assembly costs and eliminate or reduce adjustment time.

Tape contact material is supplied in long continuous lengths which simplify material handling.

In addition to supplying clad electrical contact tape material, General Plate is equipped to weld contact tape sub-assemblies for you.

Design engineers are invited to make use of General Plate contact engineering services . . . for material selection . . . parts design . . . samples.

Let us make an electrical contact cost analysis on products you want to automate. Find out how General Plate electrical contact tapes, as well as other clad contacts, can be put to work for you.

METALS & CONTROLS CORPORATION

General Plate Division

802 Forest St., Attleboro, Mass.

FIELD OFFICES: NEW YORK • CHICAGO • DETROIT • INDIANAPOLIS • MILWAUKEE • PASADENA

Circle 514 on Page 19

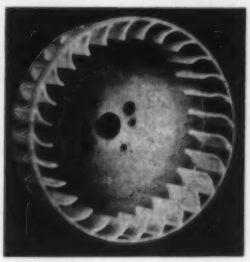
cut by a passing object, or operate on light reflected from a surface. Each type of unit has a wide range of applications in counting, positioning, monitoring, or sequencing operations. Relay box contains power relay, electronic equipment, sensitivity adjustment, and light adjustment. Relay can be set to operate at any desired threshold of light. Both lead-sulfide and cadmium-sulfide photocells are used to meet different conditions. Units measure 1½ x 1 5/16 x 11/16 in. **Ess Instrument Co.**, Bergenfield, N. J. D

Circle 698 on Page 19

Nylon Blower Wheels

for low-cost, high-performance service

Series GA nylon blower wheels are designed for installation in standard proportioned housing with unit-bearing mounting. Light in weight and noncorrosive, the four



wheels provide low-cost, high-performance service in refrigerators, movie projectors, and other small air-moving appliances. Diameters range from 2 to 3 in. **Air Impeller Div., Torrington Mfg. Co.**, Torrington, Conn. B

Circle 699 on Page 19

Centrifugal Clutch

pin-cage unit is available in 1 to 30 lb-ft capacities

Developed for rugged use when applied to electric motors and gasoline engines, pin-cage unit is governed by speed of prime mover and centrifugal force. Clutch is suitable for stand-by power applications and provides dual drive when applied to a motor or engine. It is also suitable if efficient low-slip ratio is necessary when high load factor exists. Clutch gives heavy, rugged service where positive engagement is required. Be-

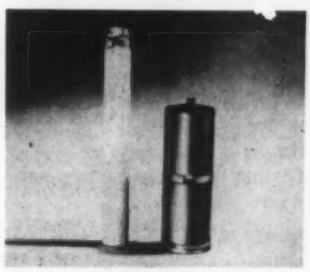
cause of positive camming action between shoes and drive pins, load locks in almost immediately and results in rapid engagement, permitting maximum torque transmission at lower operating speeds of prime mover. Pin-cage unit is available in capacities from 1 to 30 lb-ft, at 1200 to 3600 rpm. OD is 3, 3½, or 4¼ in., and bore diam is 7/16 to 1 in. Clutch can be adapted to pulley, sprocket, gear, or coupling-type drives, mounted on either drive or driven member. **Magneto Div., Fairbanks, Morse & Co.**, Beloit, Wis. K

Circle 700 on Page 19

Miniature Inertia Switches

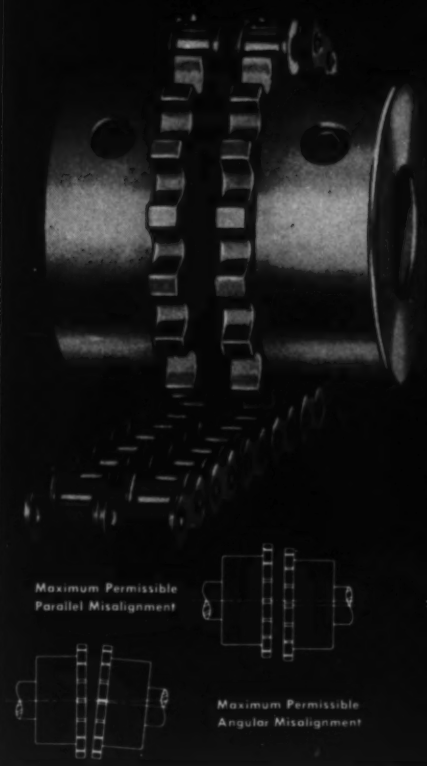
perform over −65 to 250-F temperature range

Normally closed single-pole, double-throw, or single-pole, triple-throw miniature inertia switches are actuated by acceleration, deceleration, impact, and/or shock. Acceleration sensitivity can be adjusted from less than 1 to over 100 g with accuracy of 1 per cent. Choice of contact arrangements includes momentary, latching with mechanical reset, latching with electrical reset, or latching with negative-g reset. No electrical power is required except for electrical reset. Constant performance is maintained over −65 to 250-F temperature range. Response time is less than 1 millisec. Unit resists shock of over



Another PLUS value...

PROTECTION AGAINST MISALIGNMENT



For positive protection against unavoidable misalignments...for positive power transmission...for high strength and long life...at low cost, use all-steel Rex Roller Chain Flexible Couplings. They compensate for both angular and parallel misalignment... absorb shocks and vibration...provide maximum flexibility with minimum backlash. For complete, cost-saving facts...compare! Mail the coupon.

REX®

FLEXIBLE COUPLINGS

CHAIN Belt Company 413
4643 W. Greenfield Ave.
Milwaukee 1, Wis.
(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto, Ontario.)
☐ Send me my copy of Bulletin 577.
☐ Have a Rex Man call.

Name.....
Company.....
Address.....
City.....*Zone*....*State*.....

Circle 515 on Page 19

Engineering problem:

Pressure-tight fastening of transit cases

The solution:

A specially modified LINK-LOCK

Applied Design Company engineers worked with Simmons to develop this successful LINK-LOCK application

Simmons LINK-LOCK, with design modifications developed in cooperation with the Engineering Department of Applied Design Company, Buffalo, New York, resolves special closure requirements in rigidly specified transit cases like the aluminum equipment container shown.

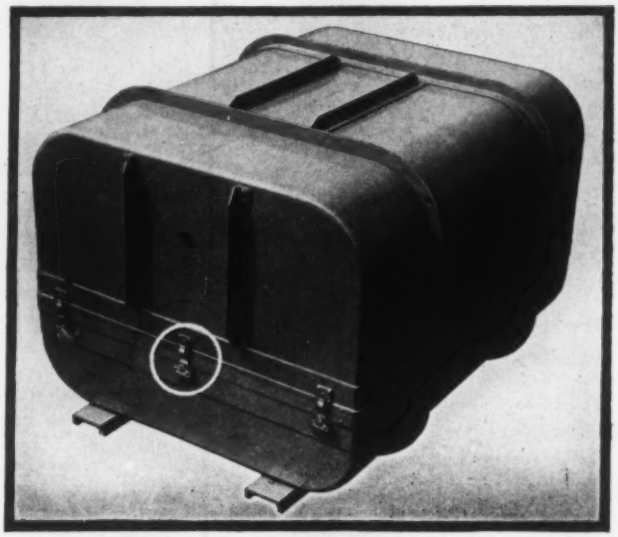
Here, the bowed LINK-LOCK engagement blade provides the double advantage of maintaining constant fastener pressure and permitting considerable mounting tolerance. This container is just one of many important products in which Applied Design specifies standard and special Simmons Fasteners.

Here's why LINK-LOCK is ideal for use on military cases produced to exacting specifications as well as on inexpensive commercial containers:

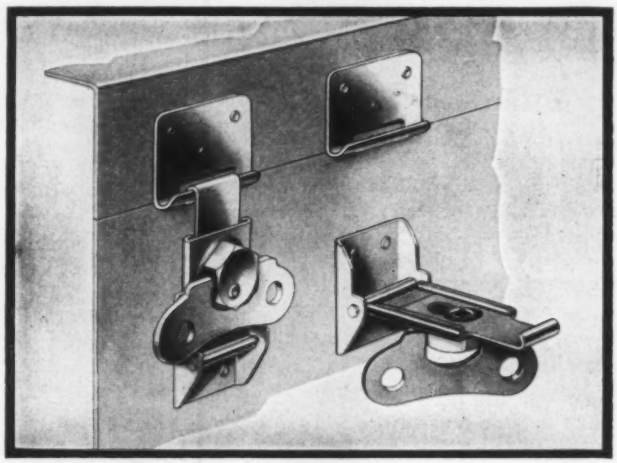
- Impact and shock resistant (positive-locking).
- High closing pressure with light operating torque... insures pressure-tight seals where required.
- Available in 3 sizes, for heavy, medium, and light duty.
- Compact design... lies flat against case even when unlocked.
- Opening and closing by wing-nut, screwhead, or hex nut.
- Flexible engagement latch design... can be varied to suit different conditions.

Also available: Spring-Loaded LINK-LOCK. Ideal for the less expensive containers where costs won't permit precision production. Spring provides take-up to compensate for set in gasketing, irregularities of sealing surfaces, and mounting inaccuracies.

SEND TODAY for the Simmons Catalog for complete information and engineering data on LINK-LOCK and other Simmons Industrial Fasteners. Engineering service is available; outline your particular fastening problems. Samples on request.



Twelve special loop-blade LINK-LOCK fasteners are used in this aluminum transit case designed by Applied Design Company.



Standard No. 2 LINK-LOCK (Medium-Duty). Available with screwhead, wing-nut as shown, or hex nut.

SIMMONS

FASTENER CORPORATION

1756 North Broadway, Albany 1, New York

QUICK-LOCK • SPRING-LOCK • ROTO-LOCK • LINK-LOCK • DUAL-LOCK • HINGE-LOCK

See our 8 page catalog in Sweet's Product Design File

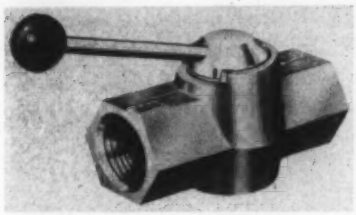
100 g and extreme vibration without damage. **Inertia Switch Div., Safe Lighting Inc.**, 527 Lexington Ave., New York 17, N. Y. D

Circle 701 on Page 19

Plug Valve

is available in four new female pipe sizes

Series 9200 plug valve, suitable for vacuum to 150-psi service in virtually all noncorrosive liquids or gases, provides absolute leakproof shut-off. It is now available in added ⅛, ¼, ½, and ¾-in. female pipe sizes. Valve is operated by a handle that opens and closes against pressure with no effort. Use of three O-rings eliminates adjusting nuts



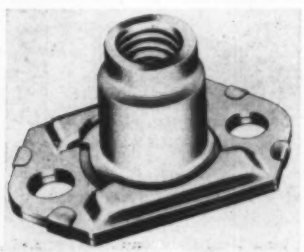
and springs and permits long, maintenance-free service life. In closed positions, one O-ring contained on surface of plug serves as a flow seal. It surrounds inlet port and provides tight shut-off. In open position, valve is full ported and allows straight-through flow passage. Static O-rings at top and bottom of plug and around circumference positively prevent stem leakage. Valve is available in brass in ⅛, ¼, ½, and ¾-in. sizes, and in stainless steel in ¼-in. size. **Circle Seal Products Co.**, 2181 E. Foothill Blvd., Pasadena, Calif. L

Circle 702 on Page 19

Floating Spacer Nut

miniature unit eliminates use of shims

Designated M13601, miniature nut is made in counterbore depths from ⅛ through ⅜ in. in 1/16-in. increments. Unit conforms to NAS-1068, except for height, and to MIL-N-25027. **Nutt-Shel Co. Inc.**, 2701 S. Harbor Blvd., Santa Ana, Calif. L



Circle 703 on Page 19

Precision Gears

five types are available from stock

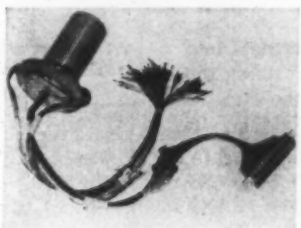
Appco stock precision gears are available in 32, 48, 64, 72, 96, and 120 diametral pitches of 14½ and 20-deg pressure angles. Gears and components meet standards and tolerances of AGMA. Each gear is mounted on a separate shipping tray and sealed with a Mylar plastic cover. Gears are available in 303 stainless steel and 24S-T4 aluminum, anodized and treated for maximum corrosion resistance. Materials and finishes meet government specifications. Gears are finished in five types: standard pin hub; slotted or clamp hub; hubless or flat; inserted pin hub; inserted clamp hub. All are offered in various bore sizes and face widths. **Atlas Precision Products Co.**, Dept. 47, 3810 Castor Ave., Philadelphia 24, Pa. E

Circle 704 on Page 19

Slip Ring and Brush Assembly

has noise level under 2 mv

With 40 circuits tied in series and with 50 ma of current flowing through slip ring and brush as-



sembly, total combined noise level of assembly is under 2 mv. Low level is maintained despite 1000 hr of operation while running at 500 rpm under vibration conditions of 10 cps, and despite temperature extremes of − 65 to 300 F. Breakaway-friction torque level is kept under 75 gm-cm. Capacitance is less than 20 mmf and insulation

Another PLUS value...

STAMINA
AT ANY ANGLE

Under loads or shocks from any angle, whether radial, thrust or combined loads, Shafer Self-Aligning Roller Bearings always retain their high load capacity. Add misalignment and the load still remains safely on the roller centers reducing retainer wear, increasing bearing life. Why? Shafer CONCAVE roller and true sphere race design—proved longer lived in thousands of installations. See your nearby distributor or mail coupon.

SHAFER®
SELF-ALIGNING
ROLLER-BEARINGS

CHAIN Belt Company 505
4643 W. Greenfield Ave.
Milwaukee 1, Wisconsin
(In Canada: CHAIN Belt Canada Ltd., 1181 Sheppard Ave. East, Toronto)
☐ Please send latest Shafer R ller Bearing Catalog.
☐ Have a Rex man call.
Name.....
Company.....
Address.....
City.....Zone.....State.....

Circle 517 on Page 19

Another Tinnerman Original...

Cost-cutting Tubular **SPEED CLIP®** takes positive "bite" to hold assemblies tight!

In seconds, you can front-mount trim, name plates, grilles, knobs, insulation, with Tubular SPEED CLIPS. And at interesting savings in assembly time and costs!

Snap these quality spring-steel fasteners into holes in metal, plastic or wood. Then press the mounting studs, nails or rivets into the clips to complete the attachments... anywhere along your assembly line.

As the SPEED CLIP is inserted, spring fingers compress, then expand behind the panel to lock tight. The rolled-in end permits easy entrance, but bites hard into the stud to prevent back-off or vibration-loosening.

Tubular SPEED CLIPS are available for a full range of stud sizes and panel thicknesses. Permanent lock or removable types.

Check your Sweet's Product Design File (Section 8/Ti) for data on Tubular SPEED CLIPS and other SPEED NUT brand fasteners. Then call your Tinnerman representative for samples and additional information. If he isn't listed under "Fasteners" in your Yellow Pages, write to:

TINNERMAN PRODUCTS, INC.
Dept. 12 • P. O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Trefforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

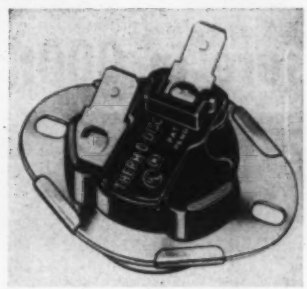
resistance is greater than 5000 megohms circuit-to-circuit and circuit-to-ground. **Slip Ring Co. of America**, 5456 W. Washington Blvd., Los Angeles 16, Calif. L

Circle 705 on Page 19

Thermostats

have high electrical rating in minimum space

Series 11-T thermostats are for operating temperatures to 350 F. They feature a high electrical rating while occupying a minimum of space. Applications include clothes dryers, washer-dryers, room and unit heaters, central-heating furnaces, and air-conditioning and ventilating equipment. Thermostats operate on free bimetal-disc principle, providing snap action of



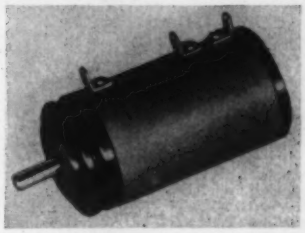
contacts and uniform operating temperatures. Calibration is factory preset and nonadjustable. Series is designed for both single-pole, single-throw and single-pole, double-throw operation. Choice of terminals includes inclined blades, vertical blades, or screw type. **Therm-O-Disc Inc.**, 127 Crouse St., Mansfield, Ohio. G

Circle 706 on Page 19

Ten-Turn Potentiometer

has linearity tolerance of ±0.3 per cent

Model 870 ten-turn, precision, wirewound potentiometer is available in ranges from 30 to 750,000 ohms and has standard linearity tolerance of ±0.3 per cent. Linearity tolerance of ±0.02 per cent is furnished on special order. Unit features precision ball or sleeve-bearing mounts at both shaft ends, and machined aluminum lids for bushing or servo-type mounting. Body is moisture-proof laminated phenolic for maximum dimensional stability and insulation resistance, and has diam-



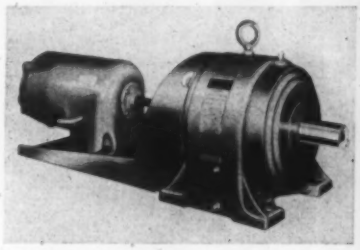
eter of 1 7/16 in. Up to 91 extra terminals can be added in addition to standard terminals to meet almost all specified requirements. **Spectrol Electronics Corp.**, 1704 S. Del Mar Ave., San Gabriel, Calif. M

Circle 707 on Page 19

Gear-Reducer Combination

has four or eight output shaft speeds

Line of combined gear-reducer and gearshift drive units includes double and triple gear-reduction units with motor capacities from 1 to 10 hp. The gear-reducer combination gives four or eight speeds on output shaft of gear reducer. By moving shift lever on gearshift drive into one of four positions, four different output shaft speeds are obtainable on gear reducer. By using a two-



speed motor in gearshift drive, eight different speeds are obtained on gear-reducer output shaft. Standard electrical characteristics are: Constant-torque, three or two phase, 60 cycle, 208, 220/440, or 550 v. **Lima Electric Motor Co. Inc.**, Dept. 139, Lima, Ohio. G

Circle 708 on Page 19

Precision Resistors

in matched sets and networks

Close-tolerance, matched resistor sets and networks are made with ratios matched as closely as 0.001 per cent and absolute values with-

Another PLUS value...

TAKES MORE LOAD, LONGER

Shafer Self-Aligning Roller Bearings, combining the low rolling friction of a ball with the greater load-carrying capacity of a roller, take severe loads easier, last longer. The inner race is a segment of a true sphere. Normal loads are carried on approximately half of the center contact area of the concave rollers, reducing friction. Under heavy loads, case-hardened races and rollers compress, increasing load-bearing surfaces. This provides exceptionally high reserve to handle shock loads and severe vibration.

This is also the right roller-race combination to handle thrust, radial or angular loads, or all even under misalignment. As a result, Shafer Bearings assure greater stamina, longer life for your equipment. See your nearby distributor, or write for latest catalog.

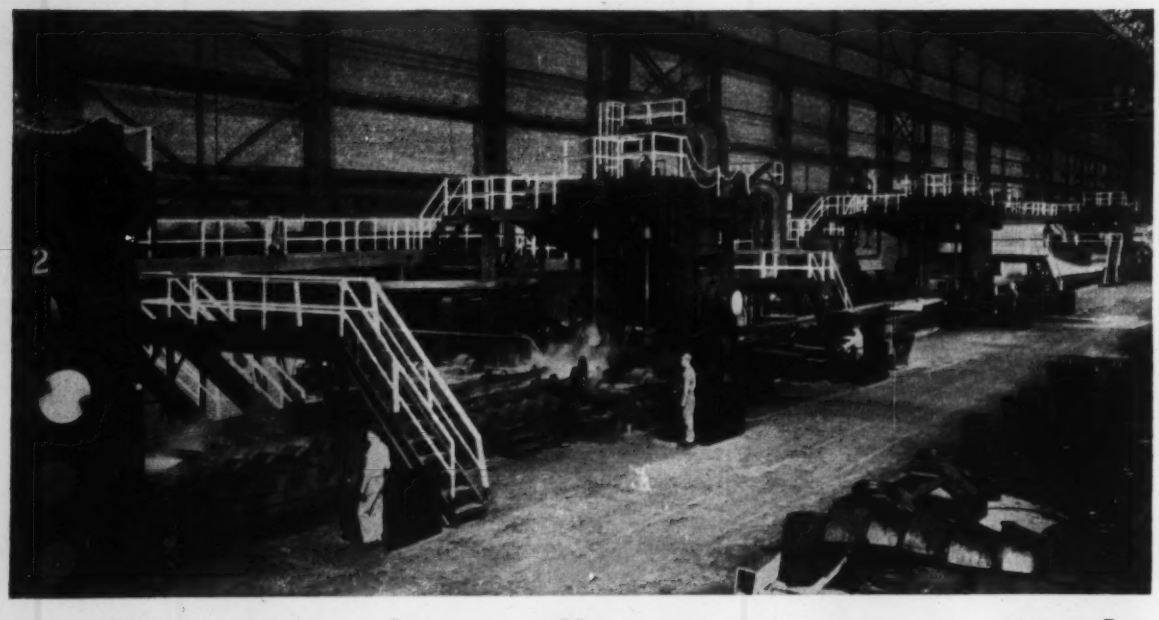
SHAFER®

SELF-ALIGNING ROLLER-BEARINGS

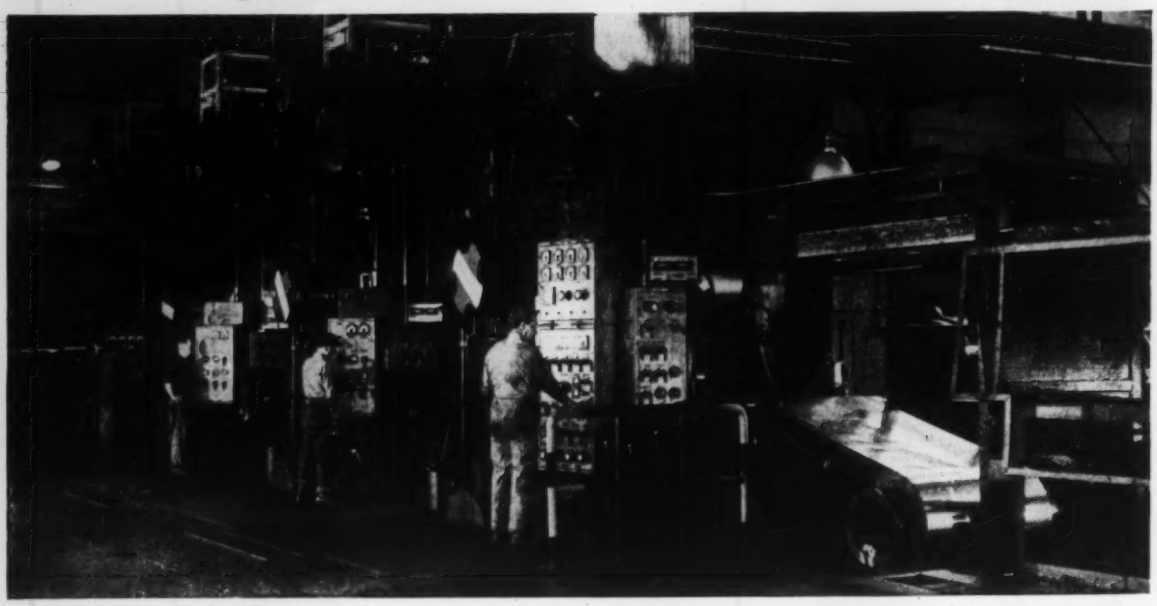
CHAIN Belt Company 506
4643 W. Greenfield Ave.
Milwaukee 1, Wisconsin
(In Canada: CHAIN Belt Canada Ltd.
1181 Sheppard Ave. East, Toronto)
☐ Please send latest Shafer Roller Bearing Catalog.
☐ Have a Rex man call.

Name.....
Company.....
Address.....
City.....*Zone*.....*State*.....

Circle 519 on Page 19



On these giant sheet mills we measure in 000ths



Shown at the top is the 68-in. continuous hot mill at our Sparrows Point, Md., plant. Entering this mill as slabs several inches thick, hot steel whizzes through at ever-increasing speeds until it emerges as hot-rolled sheet at speeds up to 2120 ft per min. The finest hot-rolled sheet steel you can buy!

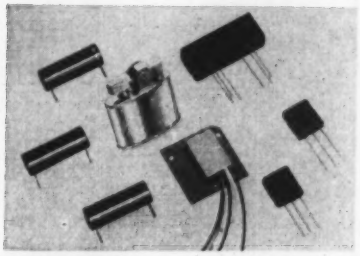
Some of this hot-rolled steel is further reduced cold at still higher speeds for use in automobile body stampings and a host of other applications. Typical of Bethlehem's up-to-the-minute facilities is the 54-inch cold mill at our Lackawanna, N. Y., plant (lower photo).

Massive though these mills are, experienced operators control thickness tolerances within a very few thousandths of an inch! And all along the line, Bethlehem sheets are carefully checked to insure uniformity of gage, surface, weight and mechanical properties.

BETHLEHEM STEEL COMPANY, Bethlehem, Pa. On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



in 0.01 per cent. Resistors are encapsulated in alkyd resin with coefficient of linear expansion the same as the resistance wire, so that temperature coefficients can be closely held. In a matched set of 13 resistors, temperature coefficient is held to zero, plus or minus one part per million. **Ultronix Inc.**, 116 S. Bayshore Blvd., San Mateo, Calif.

M

Circle 709 on Page 19

Tilting Motor Base

for all NEMA sizes through frame 505

Reaction-torque tilting motor base is for automatic belted-drive tension control under changing load conditions. Unit is available in bases to accommodate all NEMA sizes through frame 505 as well as for special applications requiring larger frames. Motor base reactive torque

is directly proportional to horsepower, and belt tension increases and decreases as load varies. **Allis-Chalmers Mfg. Co.**, Milwaukee 1, Wis.

K

Circle 710 on Page 19

Heavy-Duty Caster

is adjustable for swivel tension and thrust resistance

HiLoad swivel caster is designed to handle heavy rolling loads, such as on trailer trucks, body trucks, portable machinery, and other heavy production equipment. Caster is fully adjustable for swivel tension

The artist has captured a rare expression on the face of Sigma's general manager—one of happy satisfaction and complete contentment. This is because the sales dept. has just told him (1) about a new Machine of Pleasure which uses a Sigma product and (2) that the customer is overjoyed because the Sigma product works right. His corporate corpulence is enjoying every minute of it, while it lasts. By publicizing this latest application triumph, it is hoped that others will be spurred on to similar successes.

An enterprising consulting engineer on the West Coast recently took on the job of building a fully automatic machine for folding Chinese fortune cookies. The specs called for handling a piece of hot, flexible cookie dough every five seconds; folding it in two directions and getting the fortune inside the cookie between folds; using up 420 different fortunes before repeating. The machine slices printed fortunes as required from continuous rolls. It was at this point that consulting cookie engineer William E. Thomas asked his E. E. brother Frank how to keep the slices between the lines; since brother Frank reads Sigma ads, his immediate reply was "Sigma Photorelay" (we like to think). One was purchased and rigged up to control the paper feed, by sensing black bars printed on the rolls. Brothers Thomas, their project engineer Charles A. Lindberg (honest!), their customer and Sigma are now all entranced by the results.

So one more banner should be raised for the unsung heroes whose accomplishments do not go up in three stages and a deafening roar, but simply "kerplunk" every few seconds as a new little item is unfailingly produced. If you have such a project, and light sensing can be put to a useful purpose, a Sigma Photorelay might be worth trying. They come ready to plug in, switch 3 amps. resistive at 120 VAC, cost only about $12.00; the cookie boys even went so far as to say "we certainly could not have installed anything else that worked properly so inexpensively." Who knows, maybe you could even build a machine to get the ordinate and abcissa straight on hot cross buns.

SIGMA

SIGMA INSTRUMENTS, INC.

89 Pearl St., So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1936)

Circle 521 on Page 19

the smart move

is to **HUCK**

FASTENERS

Comments of regular users of HUCK FASTENERS tell the story.

"70% saving in our assembly cost".

"50% faster than previous methods".

"We use them wherever possible because of their strength and sealing qualities".

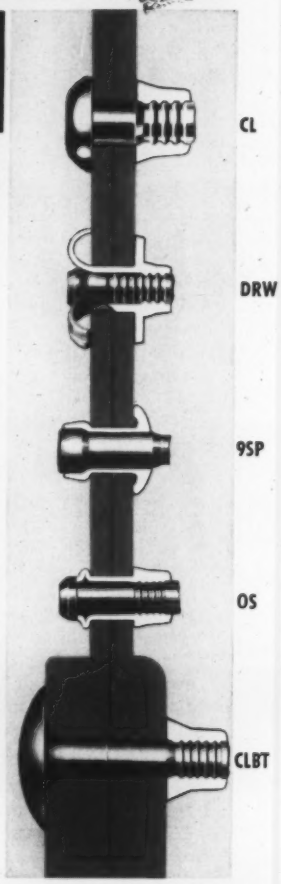
"Every fastener is automatically "torqued" identically".

"They don't slip, strip or wear loose".

Thousands of smart manufacturers have discovered that HUCK fasteners are truly the BETTER way to do their fastening job.

So mechanically predetermined is the result of the HUCK fastening system that unskilled operators can produce professional grade work almost immediately, at up to thirty fasteners per minute. Materials, sizes and head styles to meet your specific requirements.

Give us your fastening problems, our years of experience are at your service.



HUCK *MANUFACTURING COMPANY*

2480 BELLEVUE AVENUE • DETROIT 7, MICHIGAN • Phone WA. 1-6207

and thrust resistance. Grease fitting in caster yoke provides for lubrication of both raceways. Sizes range from 6 to 10 in. wheel diam. **Divine Brothers Co.**, Seward Avenue, Utica, N. Y. N

Circle 711 on Page 19

Aluminum Pipe

has walls of variable thickness

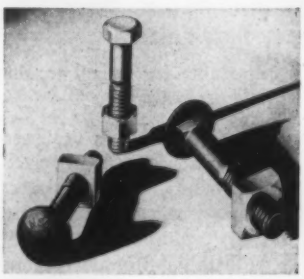
Unistrength seamless, one-piece aluminum pipe combines thin walls with standard wall thickness at pipe ends to strengthen joints. Ratio of thick to thin walls is selected to provide uniform bursting, tension, and bending strength along pipe length after welding. Decreasing wall thickness except at joints permits 40 per cent weight saving. Pipe, in 40-ft lengths, is available in alloys 6063-T6 and 6061-T6 with schedule 40 wall thickness at ends, permitting use of standard aluminum fittings and flanges. **Aluminum Co. of America**, 761 Alcoa Bldg., Pittsburgh 19, Pa. F

Circle 712 on Page 19

Carriage and Machine Bolts

in over 500 sizes

Hex-head bolts are provided in a broad range of over 500 different sizes. Full-body, hex-head machine bolts are supplied with or without

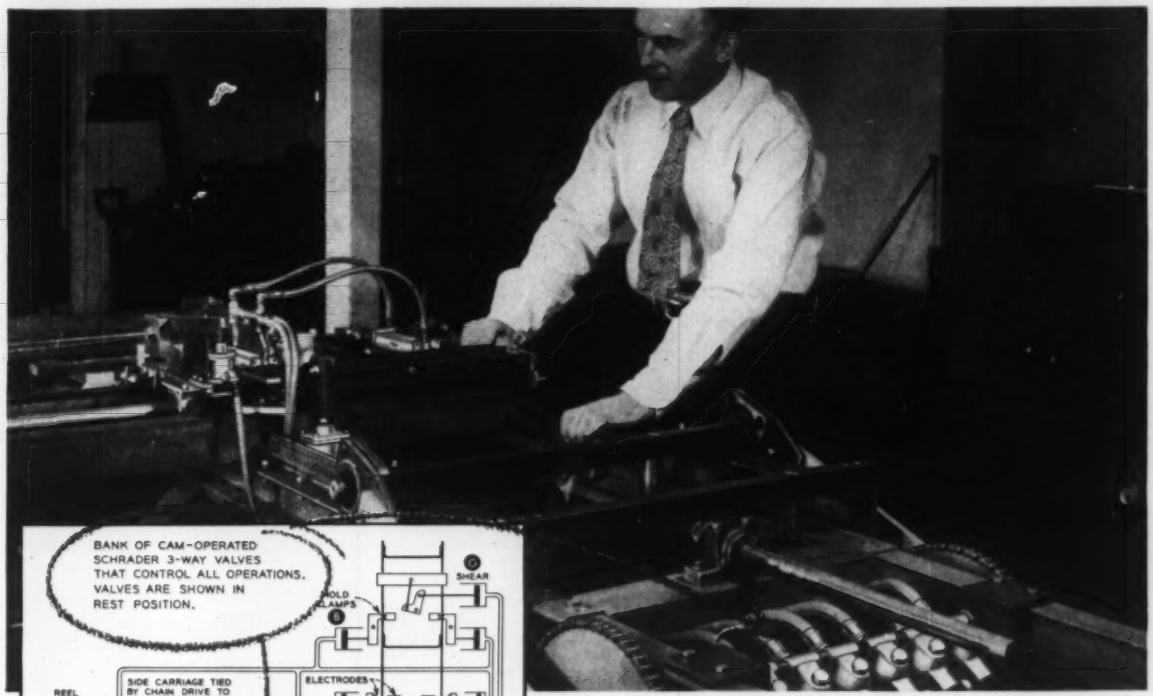


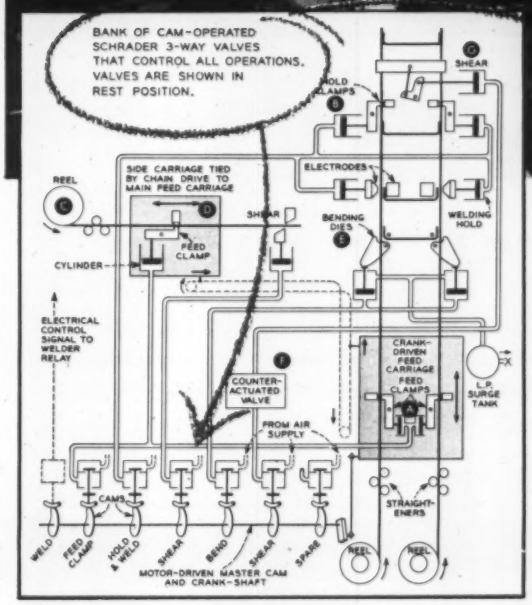
Circle 522 on Page 19

YOU, TOO, CAN AUTOMATE IT YOURSELF ...WITH SCHRADER AIR PRODUCTS

Very often you can automate manufacturing operations simply by applying Schrader air controls to existing plant facilities.

Here's a man with ideas who automated a complex job—increased production, reduced unit costs, safely and easily—without making a large capital investment. He did it with a planned Schrader air control system. Chances are excellent that you can do the same thing—with Schrader air products. Air can do an almost limitless range of work: automatic drilling, reaming, clamping and holding, shearing, forming, staking, grouping and interlocking assembly operations for quicker parts handling and assembly.





PROBLEM: Feed heavy wires into machine, shear off pieces, shape them, weld pieces together and eject as finished wire webbing. Fast. Economically. Automatically.

SOLUTION: Air Controls selected from Schrader's complete line. Neat bank of valves—actuated by cams on master cam shaft—operate synchronized system. Clamps A feed wires to holding Clamps B as carriage moves back and forth. Counter-actuated valve F operates cut-off shear G after desired number of cycles. Wire C, fed from carriage D, is sheared, formed by dies E, welded to the other two wires.

RESULT: One man performs *double* the output of three men at a fraction of the cost of a new machine.

Design it yourself! Schrader Air Control components—the most reliable self-contained power units—can help you adapt quickly to your manufacturing needs.

Schrader®
a division of SCOVILL

QUALITY AIR CONTROL PRODUCTS

A. SCHRADER'S SON • *Division of Scovill Mfg. Co., Inc.*
476 Vanderbilt Ave., Brooklyn 38, N. Y.

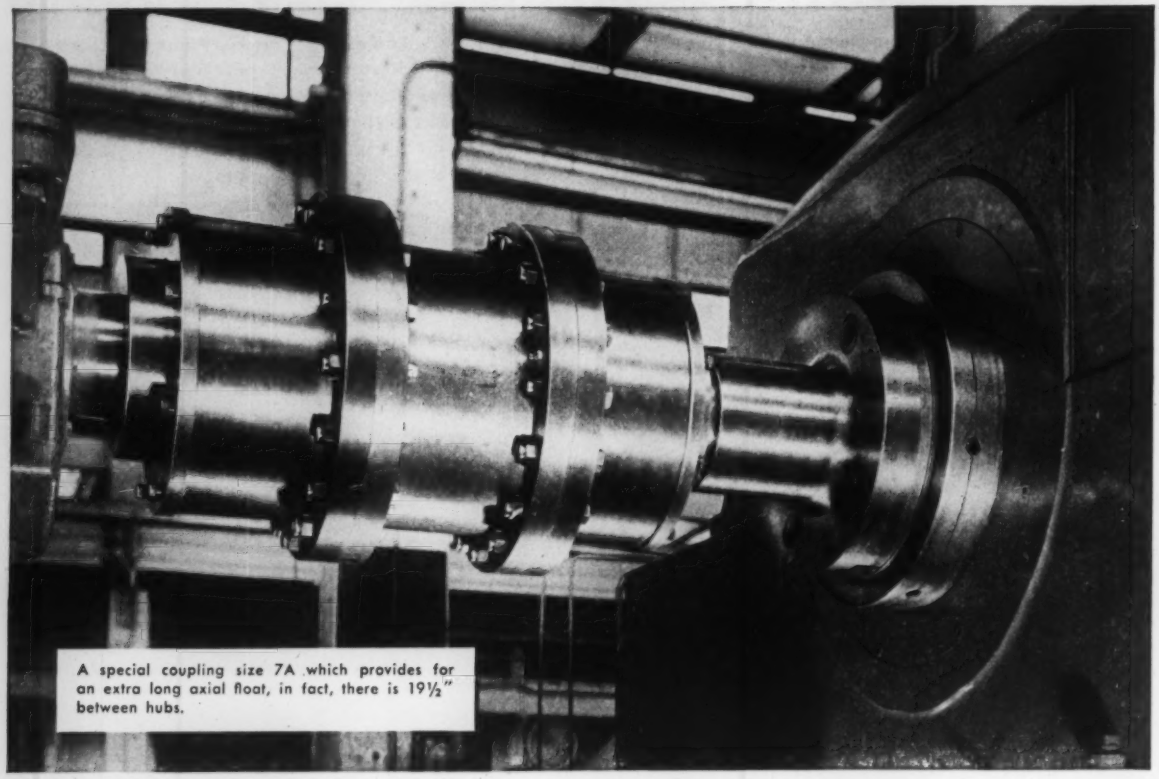
How do I start? How did others get started? Send me informative literature and information about Schrader's Automate-It-Yourself Air Products.

Name_____ Title_____

Company_____

Address_____

SPECIAL COUPLING PROBLEMS



A special coupling size 7A which provides for an extra long axial float, in fact, there is 19½" between hubs.

SOLVED

at JOHN WALDRON

From time to time, manufacturers are faced with special power transmission problems which cannot be handled by standard couplings. Sometimes they need a coupling for exceedingly high speed drives, sometimes a coupling for very large diameter shafts and for other special applications.

John Waldron, which is well known for its ability to produce high quality couplings also makes excellent special couplings to customer requirements. In the past, Waldron has made couplings that turn at speeds over 50,000 RPM, couplings which can take over 45,000 HP and couplings for particular applications such as continuous lubricated couplings, spacer types, shear pins, cut-outs and couplings for many other special installations.

If you have a particular power transmission problem that needs a special coupling, call or write the John Waldron Corporation in New Brunswick, New Jersey. Their long experience in designing, and manufacturing couplings for special problems, may have already solved your problem for you.

JOHN **WALDRON** CORP.
Subsidiary of Midland-Ross Corporation
New Brunswick, N. J.

Circle 524 on Page 19

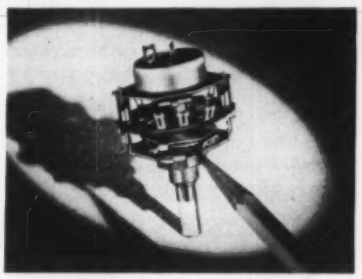
finished hexagon nuts and have minimum tensile strength of 55,000 psi. Sizes include diameters from 1/4 through 1 1/4 in. and lengths from 1 1/2 through 24 in. Carriage bolts are available in sizes from No. 10 through 3/4 in. diam, in lengths from 1/2 through 18 in. Produced with full-size bodies, they are supplied with or without regular square nuts. **Stanscrew Fasteners**, 2701 Washington Blvd., Bellwood, Ill. J

Circle 713 on Page 19

Spring-Return Switch

incorporates new steel-alloy spring

PA-070 switch eliminates the coil spring by having a steel-alloy spring built into index mechanism to control spring-return action. Switch can be supplied as a single or double-section unit, or as a single-section



unit with line switch. Up to six positions per section, including spring-return position, are available. Spring return can be placed in either first or last position. Sections are laminated phenolic Type PBE per MIL-P-3115. Voltage breakdown is 1000 v rms. **Centralab**, 900 E. Keefe Ave., Milwaukee 1, Wis. K

Circle 714 on Page 19

Gate Valves

of stainless steel for corrosive conditions

Fitted with a split wedge of ball-and-socket design which automatically adjusts to tapered seating surfaces, stainless-steel gate valves are suited to a wide range of corrosive conditions. Discs, revolving freely in wedge carrier, produce a self-cleaning action on seat which reduces possibility of galling and seizing. Two-piece packing-gland design eliminates binding of fol-

Chace THERMOSTATIC BIMETAL

ACTUATES ANOTHER PRECISION PRODUCT

The Precision Controls MOTOR PROTECTOR

More and more, our modern existence demands motor driven home appliances, ventilating equipment, automobile accessories and features and industrial mechanisms of all types. Precision Controls Company provides a tiny but effective device which protects such electric motors, both the intermittent and continuous service types, against burnouts. The bimetal element in the miniature snap-action breaker shown is so calibrated as to be responsive to electrical overloads caused by high power demands on the motor. The bimetal will also sense an abnormal rise of ambient temperature inside the motor, opening the contacts before damage is done to the motor. The precision element, of course, is Chace Thermostatic Bimetal.

Precision Controls says, "The wide range of Chace Bimetals makes our job that much easier in applying them to the wide range of requirements needed by the motor manufacturers." There was no need to mention Chace's uniformity — of alloys, of processes which create the many combinations of alloys, of precision tolerances. Absolute predictability of response, dependent on such uniformity, causes the millions of users of automobiles, appliances and machines to buy again and again without hesitation although few know of the years of development and engineering behind our precision products and our customers'. Their confidence proves our third of a century as manufacturers of thermostatic bimetal has been well spent.

While your new temperature-responsive device is in its early design stages, remember that Chace Thermostatic Bimetal is available in over 30 standard types and many specials to suit any requirement. It is also available fabricated and assembled into elements of your design or in strips or coils. Send for our booklet, "Successful Applications of Chace Thermostatic Bimetal," containing engineering data.

W. M. CHACE CO.
Thermostatic Bimetal
1616 BEARD AVE., DETROIT 9, MICH.

Circle 525 on Page 19

3 PULLEY DESIGNS

CONSTANT SPEED — Hi-Lo Automatic Pulleys employ an exclusive cam and cam follower assembly to maintain desired speed ratio over a wide range of load variation. They provide high shock absorbency against sudden changes and eliminate "drag" due to temporary overload. Sizes: ¾ to 5 hp. at 1750 rpm. Speed ratios: 1.75 up to 2.6 to 1. *Request Bulletin A458.*

HIGH RATIO — Hi-Lo Hi-Ratio Pulleys provide an extremely wide range of speeds for constant speed motors up to 1 hp. Double variable pitch feature automatically adjusts driver and driven belt speeds in accordance with distance from motor. Sizes and speed ratios: fractional to ½-hp. model up to 6 to 1, fractional to 1-hp. model up to 7½ to 1. *Request Bulletin B455-2.*

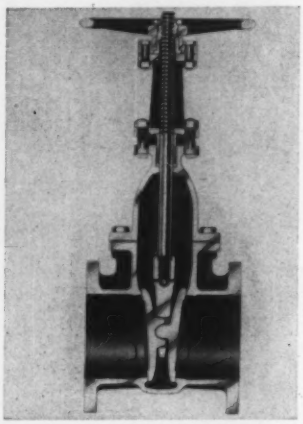
ECONOMY — Hi-Lo FHP Pulleys are low cost, high quality, compact units. They feature exclusive Hi-Lo cam design for positive speed control over a wide range of load variation. Available in three sizes: ½, ¾ and 1 hp. Speed ratios: 2 to 1 for ½ and ¾-hp. models, 2½ to 1 for 1-hp. model. *Request Bulletin C458.*

Give application details for specific information. Ask for prices.

Manufactured By HI-LO MANUFACTURING COMPANY

Nationally Distributed By LOVEJOY FLEXIBLE COUPLING COMPANY 4968H West Lake St. Chicago 44, Ill.

Circle 526 on Page 19



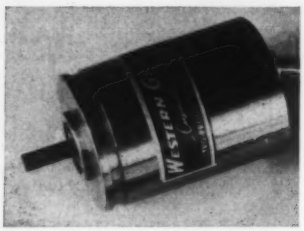
lower when gland bolts are tightened unevenly. Size range of 150-lb flanged-end valve is from ½ to 8 in., and size range of 200-lb screwed-end valve is ½ to 2 in. **Jenkins Bros.**, 100 Park Ave., New York 17, N. Y. C

Circle 715 on Page 19

Servomotors

size 10 and 11 units have stall torque of 0.6 oz-in.

Available for 26, 55, or 115-v, 400-cycle ac operation, six-pole servomotors are furnished in size 10 and 11. They have stall torque of 0.6 oz-in. minimum and no-load speed of 6500 rpm. Units operate in ambient temperatures from − 65 to 125C, are 1-11/32 in. long. **Electro Products Div., Western Gear Corp.**, 132 W. Colorado St., Pasadena, Calif. L



Circle 716 on Page 19

Spring Wire

for operation at temperatures from 650 to 1000 F

Superalloy Inconel X spring wire is heat-treatable nickel-chromium, iron, titanium material that can be precipitation hardened. It is designed for aircraft, missiles, elec-

YOU CAN CAST SAVINGS INTO YOUR PRODUCTS

There is more to a casting than a mold and molten metal. Design analysis by qualified Monarch foundry engineers, in cooperation with your engineering staff, frequently provides valuable ideas for product improvement and production savings.

Monarch's broad manufacturing operations provide the experience upon which savings can be made in subsequent manufacturing and finishing operations. These advantages are not always possible on straight competitive bidding.

Use 45 years of pioneering casting experience in

ALUMINUM PERMANENT MOLD
ALUMINUM DIECASTING and
CERTIFIED ZINC DIECASTING

Send your next inquiry to Monarch.

MANUFACTURING in MOLTEN ACHIEVEMENTS ALUMINUM

MONARCH ALUMINUM MFG. COMPANY
9205 Detroit Avenue Cleveland 2, Ohio

Circle 527 on Page 19

the ultimate in air cylinder power-

BUILT-IN ELECTRICALLY-CONTROLLED DIRECTIONAL VALVE

BUILT-IN DUAL SPEED CONTROLS

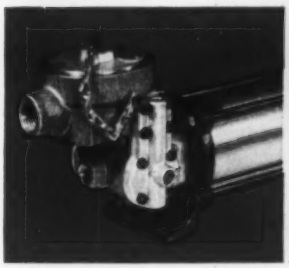
REQUIRES ONLY A SINGLE AIR CONNECTION

THE BELLOWS AIR MOTOR

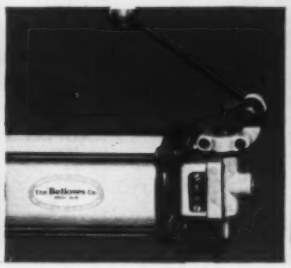
The Bellows Air Motor is a complete air cylinder power unit, with directional valve and speed controls built-in. Takes less than half the space and costs less installed than a conventional air cylinder set-up of equal power with its separate valving and piping. The single air connection, which can be made with flexible hose, makes it ideal for use on moving machine elements. It is a sturdy unit with forged steel heads, heavy brass cylinder, stainless steel piston rod. The piston rod is threaded, equipped with a wrench flat and nut. Many Bellows Air Motors have been operating day in and day out for fifteen years with negligible maintenance. And if service needs do arise, there is a Bellows Field engineer as near as your phone.

The Bellows Air Motor shown above is a 2½" bore unit equipped with the Bellows Low-Voltage (8-12V) Electroaire Valve. Other bores available are 1¼", 1¾", 3⅝" and 4½". Any stroke length. Optional choice of built-in valves as shown below.

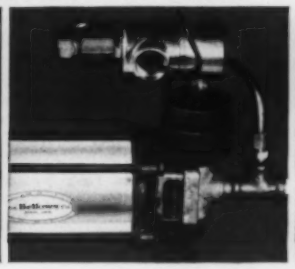
CHOICE OF BUILT-IN VALVES



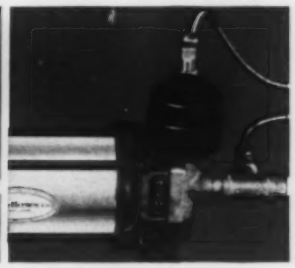
115 V. ELECTROAIRE VALVE
For J.I.C. applications where a 115 v. momentary contact is desirable.



MECHANICAL VALVE
For manual operation or for use with cams or direct linkage.



115 V. MAINTAINED CONTACT
Valve remains in shifted position during period current is applied.



AIR-OPERATED
For use in applications calling for full pneumatic control.

Write for these two booklets

Fifty pages of data to help you select the right Air Motor-Valve combination for your job. Address Dept. MD 259, The Bellows Co., Akron 9, Ohio. In Canada: Bellows Pneumatic Devices of Canada, Ltd., Toronto 18. Ask for Bulletins BM-25 and SP-55.

The Bellows Co.

DIVISION INTERNATIONAL BASIC ECONOMY CORPORATION

AKRON 9, OHIO

983-B

NOW!

Certified PRECISION STOCK GEARS

STOCK GEARS 32 TO 120 PITCH
A.G.M.A. PRECISION #3...
IMMEDIATE DELIVERY

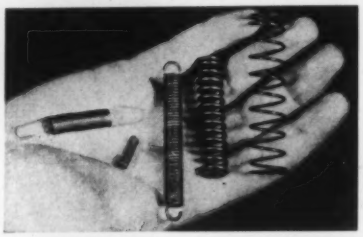
Tens of thousands of gears of all types... 32, 48, 64, 72, 96 and 120 diametral pitches of 14½° and 20° pressure angles. APPCO offers them all for quick delivery. Each one "Certified" to meet or surpass A.G.M.A. specifications.

APPCO Certified Precision Stock Gears offer 7 finishing options on aluminum gears at no extra cost... compatible bore tolerances for accurate fitting of gears, shafts and bearings. Each gear is completely sealed on shipping tray with plastic cover... always "factory fresh" and free of dust, corrosion and scratches.

APPCO Precision Gears are engineered and manufactured to allow for accurate assembly of precision units... held to tolerances that assure precise fits to standard instrument bearings, shafting, etc., according to accepted industry practice and A.G.M.A. specifications. For complete technical data and catalog write to Atlas Precision Products Co., Castor and Kensington Aves, Phila. 24, Pa.

Division of
PRUDENTIAL INDUSTRIES INC.

tronics, automotive, and other high-temperature components that operate between 650 and 1000 F. Wire is available annealed from 0.005 to 0.166-in. diam, in spring temper from 0.005 to 0.180-in. diam, and in No. 1 temper from 0.005 to 0.230-in. diam. Spring temper is recommended for operating temperatures from 650 to 750 F. Corresponding tensiles range from 190,000 to 270,000 psi, depending on wire diameter. No. 1 temper is recommended for operating temperatures from 650 to 1000 F. Corresponding tensiles, depending on wire diameter, range from 130,000 to 165,000 psi. Finishes include copper, lead, cowles lime, lime-oil, and bright. **National Standard Co.**, Niles, Mich. H

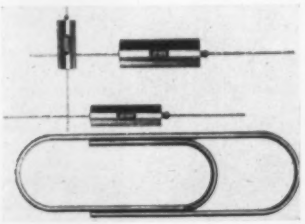


Circle 717 on Page 19

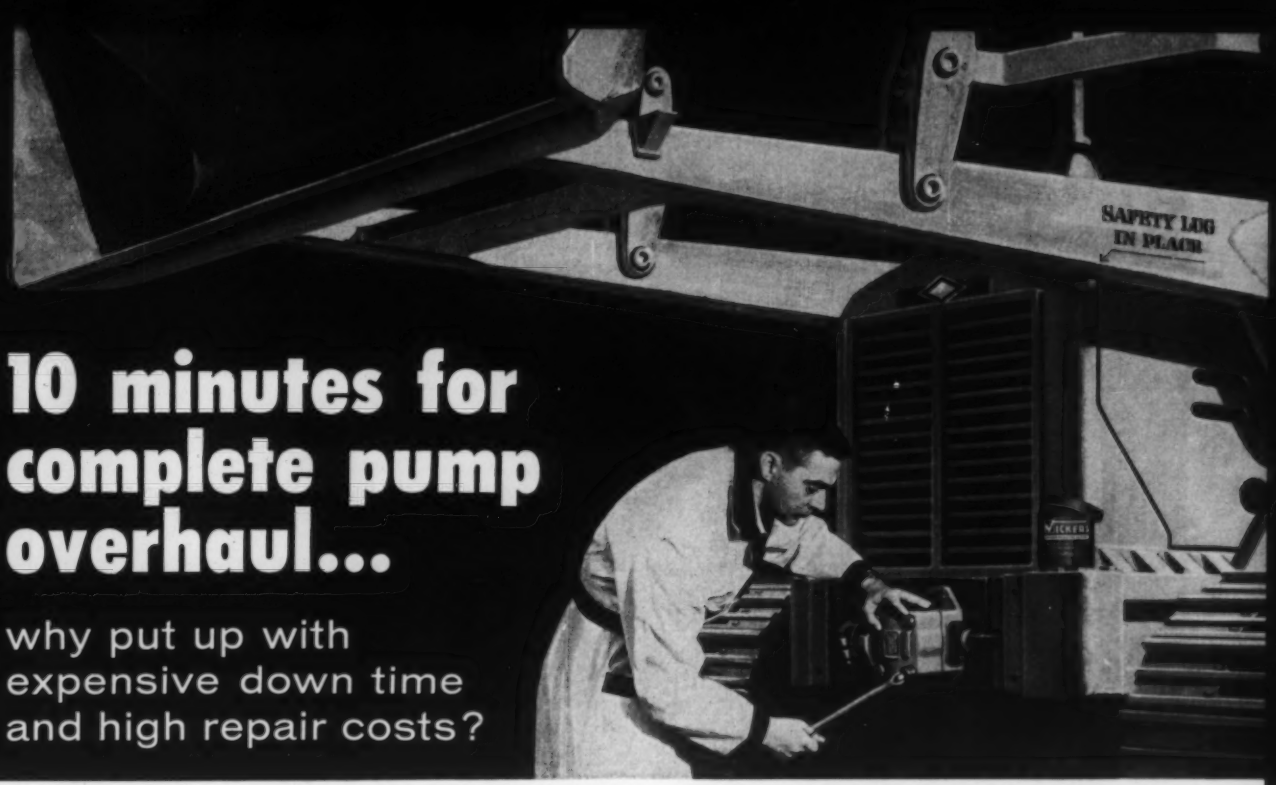
Tantalum Capacitors

subminiature units have semiconductor electrolytes

Type TES hermetically sealed capacitors have solid tantalum dielectric and solid electrolyte. Use of semiconductor electrolyte results in improved reliability over a wide range of environmental conditions. The vibration-resistant units have applications in miniaturized circuitry where high capacity and small size are required for computers, aircraft, missiles, transistorized circuits, and portable equipment. The solid tantalum units range in size from ⅛ to 11/64 in. in diam and ¼ to 7/16 in. long. Capacitance range is from 0.0047 to 47 mfd, with average variation of ±5 per cent at



Circle 529 on Page 19



10 minutes for complete pump overhaul...

why put up with expensive down time and high repair costs?

on the spot maintenance with

VICKERS®

"High Performance" Pumps*
keeps your jobs on schedule

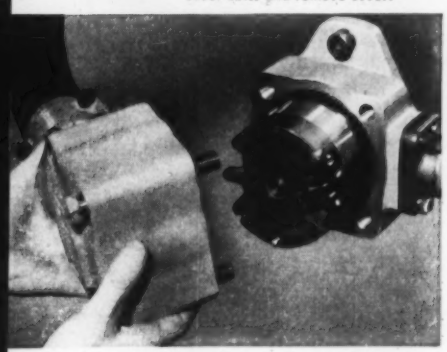
*PATS. & PATS. PENDING

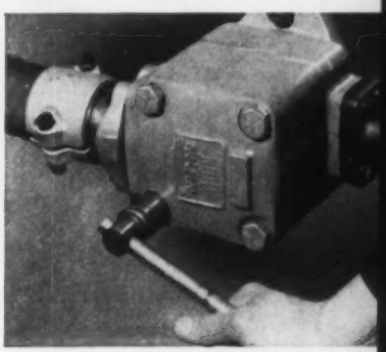
Without removing the pump from the vehicle, and without disconnecting hydraulic lines, the new Vickers "High Performance" pump can be completely overhauled by simply inserting a new pumping cartridge. The pumping cartridge contains all wearing parts in one replaceable unit and results in new pump performance. Write for Bulletin No. M5108 for performance characteristics.

1. After safety, cleanliness and draining instructions have been followed per vehicle manufacturer's recommendations, take out four cover bolts and remove cover.

2. Take out old pump cartridge and insert new one. The cartridge includes cam ring, rotor, vanes, etc. —all parts in one assembly.

3. Replace cover and you have the equivalent of a new pump ready for long, trouble-free service.





8212

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION

Mobile Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: • ATLANTA • CHICAGO • CINCINNATI CLEVELAND • DETROIT • GRAND RAPIDS • HOUSTON • LOS ANGELES AREA (El Segundo) • MINNEAPOLIS • NEW YORK AREA (Springfield, N.J.) PHILADELPHIA AREA (Media) • PITTSBURGH AREA (Mt. Lebanon) PORTLAND, ORE. • ROCHESTER • SAN FRANCISCO AREA (Berkeley) SEATTLE • ST. LOUIS • TULSA
ALSO SOLD AND SERVICED IN AUSTRALIA, ENGLAND, GERMANY & JAPAN
IN CANADA: Vickers-Sperry of Canada, Ltd., Toronto, Montreal & Vancouver

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 530 on Page 19

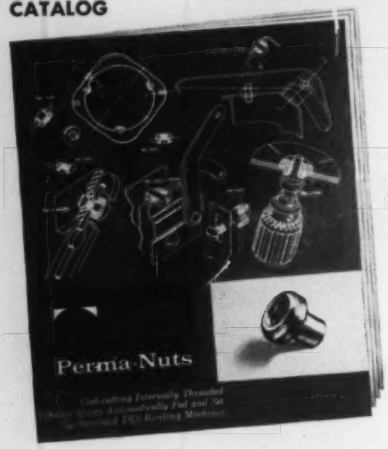
ATTACHMENT and FASTENING

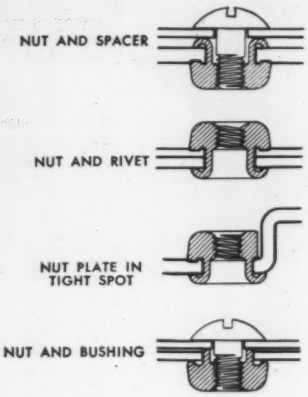
PROBLEM SOLVER

Applied with standard TRS riveting machines

Solve design problems with PERMA-NUTS and get the speed and economy in production that goes with automatic feeding and setting of standard tubular rivets. An important advantage of this unique combination nut and rivet! A built-in "lock washer" feature is another.

WRITE FOR CATALOG





TUBULAR RIVET & STUD CO., *Quincy 70, Mass.*

Circle 531 on Page 19

VALLEY BALL BEARING MOTORS

Custom Built . . .
NOT Custom Priced!

AIR COOLED

- POLYPHASE, 50 OR 60 CYCLES
- SQUIRREL CAGE INDUCTION
- HIGH TORQUE
- ½ TO 75 H.P.

Cool Running . . . Continuous Service . . .

that's the axiom Valley Motors live up to.

They have been tested and proven in every industry where dependable service and power is a requirement. Remember they are semi-enclosed to assure protection against dripping or splashing liquids, metal chips and abrasive dust.

WRITE FOR COMPLETE INFORMATION

VALLEY ELECTRIC CORPORATION
4221 Forest Park Blvd. • St. Louis 8, Mo.

Circle 532 on Page 19

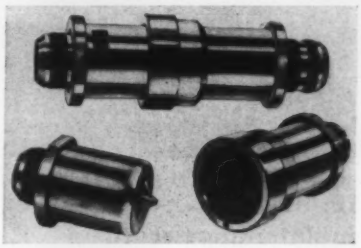
25 C. Units operate at full rated working voltage over temperature range from −80 to 85 C. **Astron Corp.**, 255 Grant Ave., East Newark, N. J. D

Circle 718 on Page 19

Disconnect Coupler

handles liquid oxygen and nitrogen

Heavy-duty slip-joint type coupler disconnects with a negligible breakaway force. Made of 300-series stainless steel, chrome plated in wear areas, it handles liquid oxygen and liquid nitrogen. Operating pressure



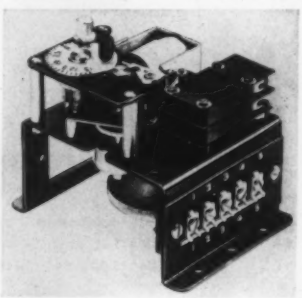
is from 0 to 500 psi with proof pressure of 1000 psi. Leakage at 0 to 160 psi, both connected and disconnected, is zero. Operating temperature range is −325 to 500 F. Coupler is available in ½, ¾, 1, and 1½-in. tube sizes. **Bruning Co.**, 601 S. Ninth St., Lincoln, Nebr. I

Circle 719 on Page 19

Time-Delay Relay

provides broad application flexibility

Type 471 relay provides an accurate, adjustable time delay between operation of a control circuit and subsequent transfer of one or two load switches. Through selection of external wiring connections, unit offers broad application flexibility and



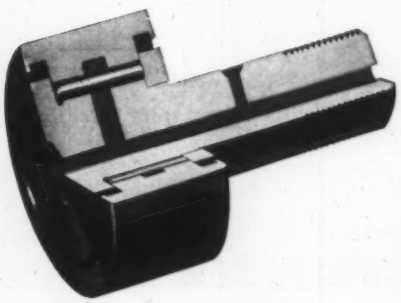
only McGILL® sealed *CAMROL*® cam followers give you . . .

effective sealing

prelubrication

high radial and shock capacity

in a full range of sizes



Effective sealing of the CAMROL cam follower against moisture, dirt, chips, etc. guarantees longer service life . . . reduces maintenance. This sealed construction retains lubricant and eliminates need for frequent relubrication, so often undesirable in cam action, guide support and track roller applications.

Special seals are built in at stud and flange ends. A black oxide finish on all exposed surfaces offers outside corrosion resistance. The channeled reservoir above the rollers in the outer raceway bore helps store reserve lubricant, sufficient in most cases for lifetime service. Relubrication is possible through convenient oil holes. The new SCF sealed CAMROL cam followers interchange with proven standard CAMROL cam followers. Standard stock with roll diameters up to 4″ are available for both stud and shaft mounting.

For maximum bearing life where contamination is a problem, specify sealed CAMROL cam followers. Ask your McGill representative or our engineering department for recommendations.

Write for Catalog No. 52-A

engineered electrical products

McGILL®

precision needle roller bearings

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 NORTH LAFAYETTE ST., VALPARAISO, INDIANA

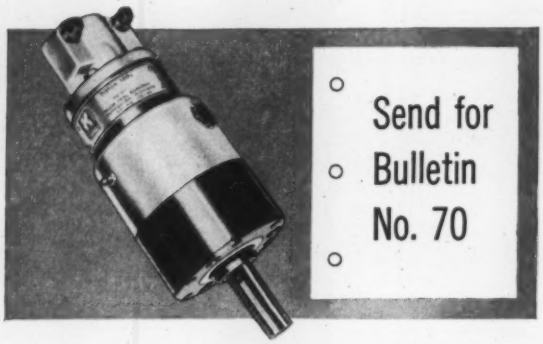
Idea-packed power for the challenge of tomorrow

Where power needs call for...

- High starting torque
- Reversibility without power loss
- Variable speed, easily controlled
- Cool operation
- Instantaneous starts and stops
- Consistent torque output
- Nonsparking characteristics
- Thrust or axial spindle loads
- Enclosed construction
- Output from ⅛ to 16 hp

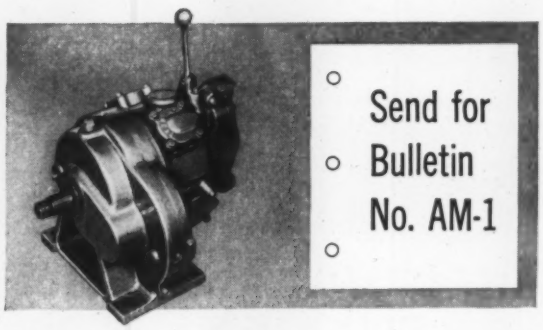
Air motors are the answer

Call your Gardner-Denver air tool specialist soon or write for bulletins.



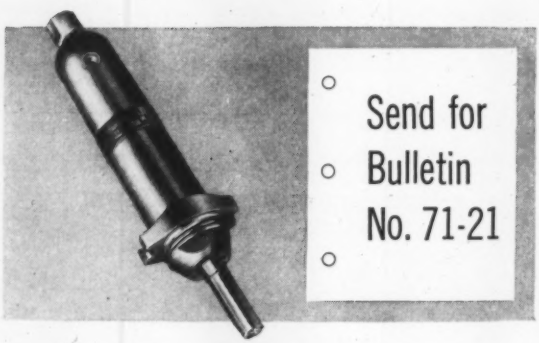
Send for Bulletin No. 70

Axial Piston Air Motors, 0.6 to 2.7 hp



Send for Bulletin No. AM-1

Five-Cylinder Radial Air Motors, 3 to 16 hp



Send for Bulletin No. 71-21

Rotary Vane Air Motors to 1.6 hp

AT HOME A LONG WAY FROM HOME

Factory-trained specialists in Gardner-Denver plants and offices throughout the world have parts and facilities to keep our products on the go—wherever they go. At Gardner-Denver *there's no substitute for men*—our 100-year philosophy of growth.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

excellent accuracy at moderate cost. Typical uses include control of machine tools, batch processes, heat treating, automatic mixers, electronic devices, and signalling equipment. Time ranges from 15 sec to 24 hr. Adjustment range is from about 10 to 100 per cent of full scale. Switch ratings are 10 amp, 125 v, or 5 amp, 250 v ac resistive. Motor and clutch ratings are 115 and 220 v, 25, 50, and 60 cycles. **Cramer Controls Corp.**, Centerbrook, Conn. B

Circle 720 on Page 19

Switch-Light

for panel mounting

Double-pole, double-throw, double-break switch-light combination with independent 28-v lamp circuit is designed for panel mounting. Unit is supplied in momentary snap action or push-on, push-off snap

action. Contacts are rated 5 amp inductive at 28-v dc. Operating pressure is approximately 4 lb, with 5/32-in. over-all travel and 5/8-in. mounting thread. Switch case is 7/8 in. in diam. Length from mounting surface to and including terminals is 1 3/8 in. **Switch Div., Pendar Inc.**, P. O. Box 3355, Dept. EE, Van Nuys, Calif. L

Circle 721 on Page 19

Ball Valves

for missile and ground-support uses

Ideal for use with standard fuels and oils, high-energy fuels, coolants, and cryogenics, ball valves are available for missile in-flight and ground-support applications. Combining simple design and rugged construction, they are extremely light and compact. When functioning as drain, selector, fill, and flushing valves, ball-type design can be ac-

From Overloads — Costly Damage — Downtime

Whitney-Tormag Drive gives you everything you've been looking for in a protective drive. You get smooth, cushioned starts, complete protection from overloads and damage caused by stalls and jamming. *Plus*, a Whitney-Tormag Drive is the only self-contained unit which will run under *full stall conditions for extended periods*... without overheating or overloading the motor or driven equipment. And Magnetic Torque never wears out — permanent magnets eliminate fluids, particles, seals and pumps... cuts power drainage!

SEE HOW WHITNEY-TORMAG DRIVES MEET EVERY REQUIREMENT!

FEATURES	Whitney-Tormag Drives	Shot Loaded Centrifugal Drives	Fluid Loaded Drives
Torque Limiting (independent of input speed)	Yes	No	No
Overload Protection (under full stall)	Yes	No	No
Indefinite Full Stall	Yes	No	No
Shock Absorbing	Yes	Partial	Yes
No Wearing Surfaces	Yes	No	Yes
One Design for All Installations	Yes	No	Yes
Smooth Load Pickup	Yes	Variable	Yes
Independent of Input Speed	Yes	No	No
Independent of Direction & Frequency of Reversal	Yes	No	No

Whitney-Tormag Drives are available through your local Whitney Chain Distributor in 1, 2, 3 and 5 H.P. (at 1750 RPM input) sizes, additional sizes up to 15 H.P. will follow.

Write for new catalog, giving complete description and details.

A PRODUCT OF Whitney • CHAIN COMPANY

304TC HAMILTON STREET • HARTFORD 2, CONNECTICUT

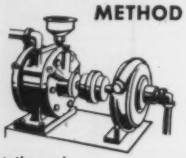
ROLLER CHAIN • CONVEYOR CHAIN • SPROCKETS • FLEXIBLE COUPLINGS • WHITNEY-TORMAG DRIVES

Circle 535 on Page 19

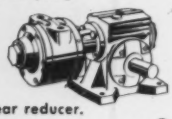
Six sizes . . .
all variable-speed
explosion-proof

GAST rotary vane AIR MOTORS

CHOOSE YOUR DRIVE METHOD



Direct through flexible coupling.



Use gear reducer.

Flange mounted – vertical operation.

Driving pulley.

Need a compact, low-cost motor for original equipment or plant use applications? *Air may be your answer . . .* using one of these efficient Gast rotary-vane Air Motors. Look at the special advantages they offer you:

1. They're explosion-proof — no sparks, no danger!
2. Low initial cost compared to other motors.
3. Speed variable with simple valve control.
4. Can't burn out if overloaded or stalled.
5. Reversible rotation optional on some models.
6. Rotor vanes take up their own wear.
7. Quickly attached to plant air lines.
8. Amazingly light, compact for h.p. delivered.
9. Ball-bearing; almost service-free design.
10. Mechanically simple, neat in appearance.

Gast Air Motors are supplied as original equipment on pneumatic hoists, mixers for paint and chemicals, fans, blowers, fuel hose-reel rewinders, liquid pumps, spooling machines and a host of other products. Used in explosive atmospheres and in "hot" locations to 250° F.

Model No.	1AM	2AM	4AM	6AM	8AM	16AM
H.P. at 90 P.S.I., 2000 RPM	0.13	0.57	1.1	2.0	4.0	7.0
Weight, lbs.	1½	5½	8	17	25	65

For complete performance data, write for Air Motor Bulletins. Specify models that interest you.

GAST MANUFACTURING CORP., P.O. Box 117-P, Benton Harbor, Michigan

SEE CATALOG IN SWEET'S PRODUCT DESIGN FILE & A.S.M.E. CATALOG

GAST ROTARY

- AIR MOTORS TO 7 H.P.
- COMPRESSORS TO 30 P.S.I.
- VACUUM PUMPS TO 28 IN.

"Air may be your answer!"

Circle 536 on Page 19

tuated by manual, mechanical, or electrical means. **Koehler Aircraft Products Co.**, 409 Leo St., Dayton 4, Ohio. G

Circle 722 on Page 19

Epoxy Molding Powder

has excellent electrical characteristics

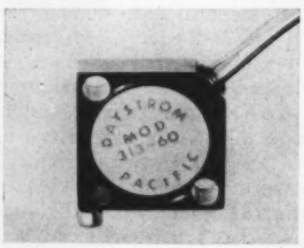
Hysol 8610 is a one-component powder which offers long storage stability, low shrinkage on cure, excellent electrical characteristics at elevated temperatures, and good dimensional stability. Having a heat-distortion point exceeding 150 C, it offers fast cure at moderate temperatures, and good flow characteristics. Applications include coil and resistor bobbins, shells for electrical components, relay assemblies, connector plugs, and switchgear. **Molding Dept., Houghton Laboratories Inc.**, Olean, N. Y. N

Circle 723 on Page 19

Miniature Potentiometer

for high-temperature applications

Squaretrim ½-in. precision potentiometer, designated Model 313, is available in resistance values from 10 ohms to 50 K±5 per cent. Operating temperatures of the miniature 1.5-w unit range from −55 to 200 C. Potentiometer also meets or exceeds MIL-STD-202, Method 202, shock and vibration, and NAS 710 noise specifications. A 360-



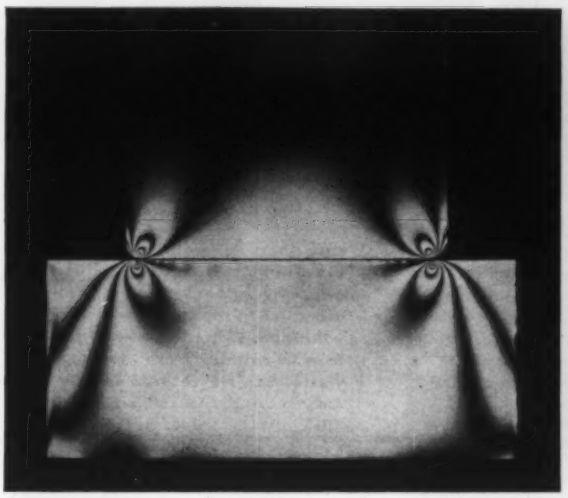
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

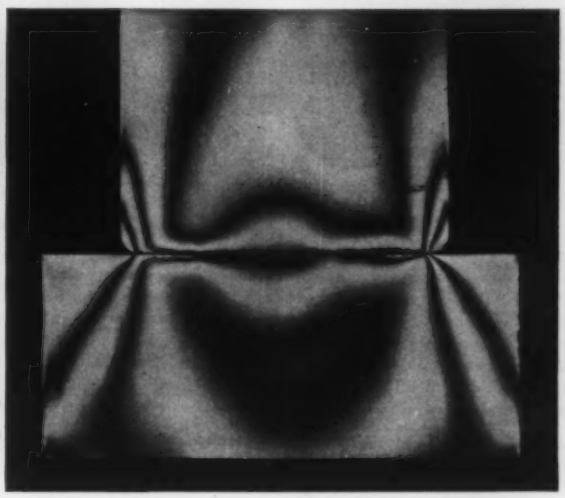
TEAR OUT AND PUNCH AS INDICATED FOR YOUR FILE

One in a series of technical reports by Bower

BEARING BRIEFINGS

ROLLER BEARING LIFE AND CAPACITY LINKED TO STRESS DISTRIBUTION





These reproductions of photoelastic studies contain important evidence for every engineer and designer concerned with the performance and selection of roller bearings. In these photographs, the alternate dark and light areas, called fringes, indicate not only the magnitude of stress but also the stress distribution. The photographs were taken by Bower Research Engineers during a study of stress distribution in roller bearings.

The subjects represent rollers and raceways of two roller bearings under identical loads. The illustration at the left shows a roller of conventional design. The illustration at the right shows a Bower "Profiled" roller. That is, the roller is precision ground with a large radius generated along the body of the roller—a predetermined and controlled distance from each end.

The conventional roller photo (left) clearly shows how, under load, stress concentration builds up in and near the roller ends. This is called edge-loading. Such areas of concentrated stress are the breeding grounds for metal fatigue and eventual bearing failure.

In the photo of the "Profiled" roller (right) stress lines can be seen uniformly distributed across the whole length of the roller and raceway. There are no points of excessive stress concentration, consequently no starting points for early fatigue. Such a "Profiled" roller exhibits a great advantage in improved load carrying capacity, a most important bearing requirement.

Under actual operating conditions, Bower "Profiled" roller bearings show a considerably longer life at higher speeds and under greater loads than conventional roller bearings.

Because of this, and of other Bower features to be discussed in later technical reports, we suggest that you consider the advantages of Bower bearings in satisfying your future bearing requirements.

★ ★ ★ ★

Bower engineers are always available, should you desire assistance or advice on bearing problems. Where product design calls for tapered roller bearings or journal roller assemblies, Bower makes these also in a full range of types and sizes.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION – FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

Circle 537 on Page 19

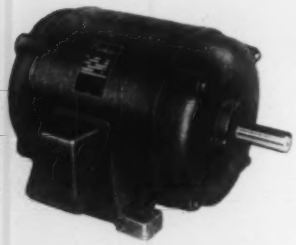
PEERLESS SPECIAL AND STANDARD ELECTRIC MOTORS

Peerless specializes in customer-manufacturer teamwork engineering of special motors. Unusual operating conditions and duty requirements are everyday problems to us. We are the exclusive motor supplier to many original equipment manufacturers. Our knowledge works to your advantage in reducing the engineering time required to solve your motor problem.

TYPES and RATINGS

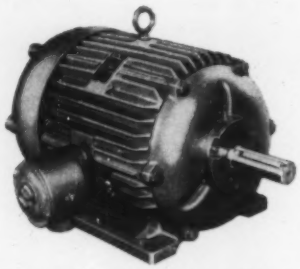
Single Phase	½ thru 10 HP
Polyphase	½ thru 30 HP
Direct Current	¼ thru 3 HP
TEFC (single phase)	1 thru 10 HP
TEFC (polyphase)	1 thru 30 HP
Explosion-Proof	Same as TEFC
Torque	2 oz. in. to 200#ft.

Special Designs to Specifications



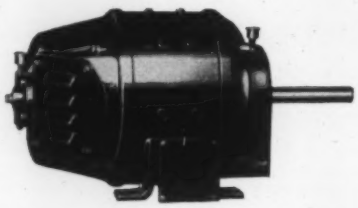
DRIP-PROOF (open type)

Completely protected against dripping liquids and falling particles. Surfaces are smooth and symmetrical. Frame sizes from 56 to 324 as shown. Frames 324 and 326 have welded frame. Cast-iron construction. Sleeve or ball bearings.



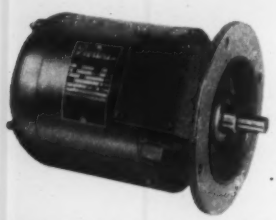
TEFC and EXPLOSION-PROOF

External fan draws cool air across motor toward driven machine. Heat from machine is not drawn across motor. Explosion-proof designs approved for Class I and II duty. Special mounting designed to meet application requirements. For HP ratings see table above.

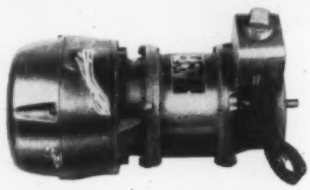


DIRECT CURRENT

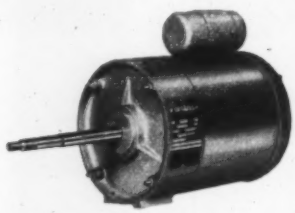
Designed for rough usage. High starting torque, good overload capacity and high electrical efficiency. Shunt, series or compound windings. Constant speed generators in ratings from 150 to 3000 watts. See HP ratings above.



WEATHER-TIGHT SPECIAL FLANGE



EXPLOSION-PROOF TORQUE MOTOR WITH BRAKE



SPECIAL FLANGE REVERSING HOIST MOTOR, SINGLE PHASE

ENGINEERING DATA—These bulletins are available from Peerless: Space-Saver, SP-1; Torque, T-1; and SDA-155 describing the complete line. Peerless builds many special mountings. Various modifications—special shaft features; paint and varnish treatments; Class A, B, F, H insulation, etc. are available. Peerless builds to the standards and specifications of JIC, AIEE (including AIEE No. 45 Marine Duty), ABS, Federal and Military.

ELECTRIC MOTOR DIVISION

THE *Peerless Electric*® COMPANY

FANS · BLOWERS · MOTORS

1520 W. MARKET ST. · WARREN, OHIO

Circle 538 on Page 19

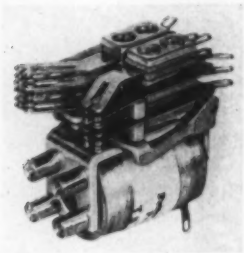
deg sweep of wiper requires 42 turns of adjustment screw, providing fine precision adjustments. Instrument offers excellent resolution. **Potentiometer Dept., Daystrom Pacific,** 9320 Lincoln Blvd., Los Angeles 45, Calif. L

Circle 724 on Page 19

Telephone-Type Relay

short-coil unit permits high contact loads

Modified TS short-coil telephone-type relay features bifurcated contact arms with up to 20 arms per relay. It provides longer and more reliable operating life, permits higher contact loads, and requires only 3/16 in. added to previous over-all length. Unit operates on as little



as 100 mw per movable arm and can be furnished to operate on voltages up to 110 v dc. It will switch up to 4 amp at 115-v, 60-cycle, resistive loads. **Potter & Brumfield Inc.,** Technical Information Dept., Princeton, Ind. J

Circle 725 on Page 19

Drum Switch

for starting and reversing of motors

Used for across-the-line starting and reversing of ac polyphase squirrel-cage motors, Type DR drum switch can also be used with single-phase motors built for reversing duty, and with dc shunt, series, and compound motors. Switch provides easy conversion from maintained to momentary contact. Size 00, with three poles arranged to break two lines to motor, is rated 1 hp maximum at 115 v ac, single phase or 220 v ac polyphase. Size 0, with contacts arranged to break three lines to motor, is rated 1 hp maximum at 115 v ac, single phase, to 2 hp maximum at 440-

Make your next connection with

asg

UNIVERSAL JOINTS

They are made to provide smooth, more efficient transmission of power and are available from stock in 13 sizes with bored or solid hubs ranging from .375" to 4.000". Special bores, bores with keyways or setscrews are available upon special order.

The close limits to which all parts are held assure maximum load carrying capacity with durability and long life. All parts are made of preheat-treated alloy steel and are precision ground to insure high quality and interchangeability of components. Joints with hub diameters of .750" and larger have a self-closing snap ball oiler while the small pin is held in place with a self-locking snap ring. The snap ring simplifies assembly and disassembly.

Send today for Bulletin No. 527 describing the full line of ASG Universal Joints available from your nearest distributor.

AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY HARVEY, ILLINOIS, U.S.A.

Circle 539 on Page 19

NEW 2" TO 3 3/8" CENTER HYGRADE WORM GEAR SPEED REDUCERS

1/3 TO 5 HORSEPOWER INPUT

Now—Foote Bros. offers the longer service life, greater capacity-for-size, more compact design and extra quality of famous Hygrade Reducers in 96 new combinations.

Advanced worm gear design and Foote Bros. precision production techniques make these new Hygrade Reducers the most efficient and economical power packages you can buy. And they're easier to select and buy, because Foote Bros. Distributors and Branch Warehouses carry them in stock ready for immediate delivery.

IN STOCK at Your Nearby FOOTE BROS. Authorized Distributor

Write for Stock Products Catalog

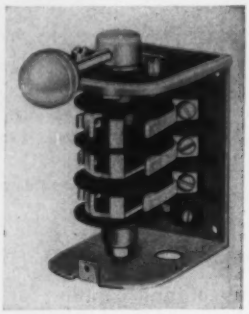
100 YEARS 1859-1959 FOOTE BROS.

Better Power Transmission Through Better Gears

FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 SOUTH WESTERN BOULEVARD • CHICAGO 9, ILLINOIS

Circle 540 on Page 19



550 v ac, polyphase. Both sizes have NEMA 1 enclosures designed for easy surface mounting direct to machine. **Arrow-Hart & Hegeman Electric Co.**, Dept. MD, 103 Hawthorn St., Hartford 6, Conn. B

Circle 726 on Page 19

Solid-film Lubricant

for moving parts operating in oil and grease

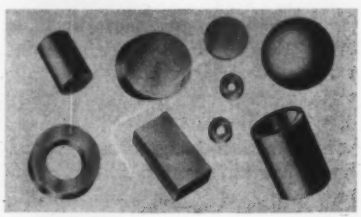
No. 4856 lubricant contains small particles of lead, tin, and graphite, well known for their ability as bearing materials. Lubricant increases wear life of moving parts operating in oil or grease. Semiporous nature of the coating absorbs oil and acts as a reservoir against metal-to-metal contact under high loads. Lubricant is also compatible with additives in modern oils and greases. Typical applications include spherical bearings, clutch assemblies, leather oil seals, spline assemblies, bearing cages, sleeve bearings, piston cylinders, valve stems, and hydraulic actuator parts. **Electrofilm Inc.**, P. O. Box 106, North Hollywood, Calif. L

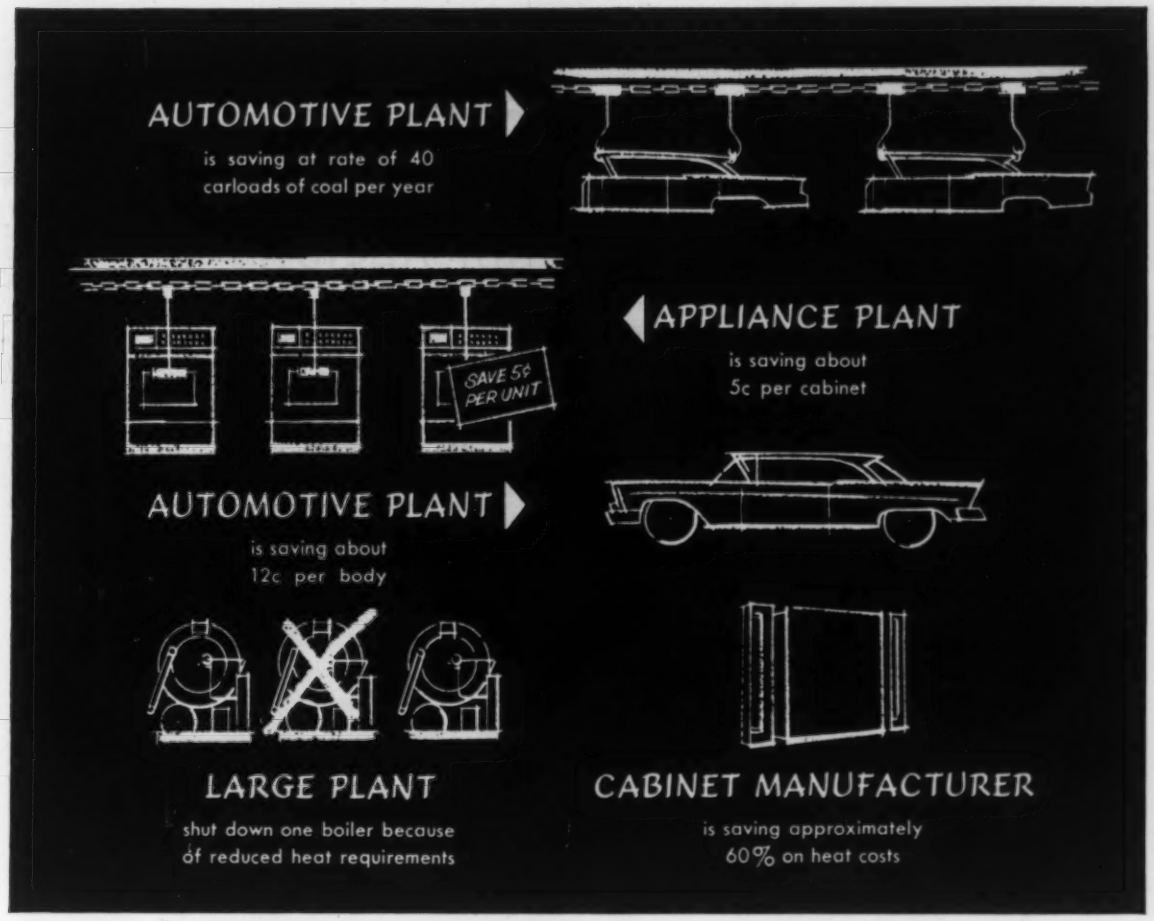
Circle 727 on Page 19

Ceramic Transducer Element

has high-frequency stability

US 100 ceramic transducer element is extremely stable over wide temperature range. It is suitable for use in equipment that is subject to drastic temperature variations, in-




AUTOMOTIVE PLANT
is saving at rate of 40 carloads of coal per year
SAVE 5¢ PER UNIT
APPLIANCE PLANT
is saving about 5c per cabinet
AUTOMOTIVE PLANT
is saving about 12c per body
LARGE PLANT
shut down one boiler because of reduced heat requirements
CABINET MANUFACTURER
is saving approximately 60% on heat costs

high quality coatings... spectacular savings, too! New COLD BONDERITE SYSTEM

These are not isolated cases. Everyone saves when they change from conventional hot phosphating to the new Cold Bonderite System!

The difference is in heat required. Cleaner, rinse and Bonderite operate 40° to 75° cooler than in conventional installations.

Results produced by the Cold Bonderite System equal the highest Bonderite quality standards. Chemical costs are comparable to hot systems.

Many plants, from the largest on down, have changed to the Cold Bonderite System in their finishing lines. They've cut costs drastically. You can, too. Write or call today!

PARKER RUST PROOF COMPANY
2193 E. MILWAUKEE, DETROIT 11, MICHIGAN

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

Since 1914 — leader in the field

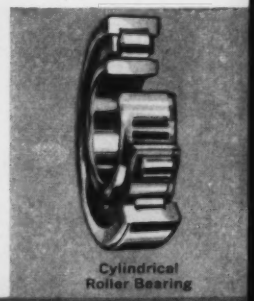
*Bonderite, Bonderlube, Parco, Parco Lubrite—Reg. U.S. Pat. Off.

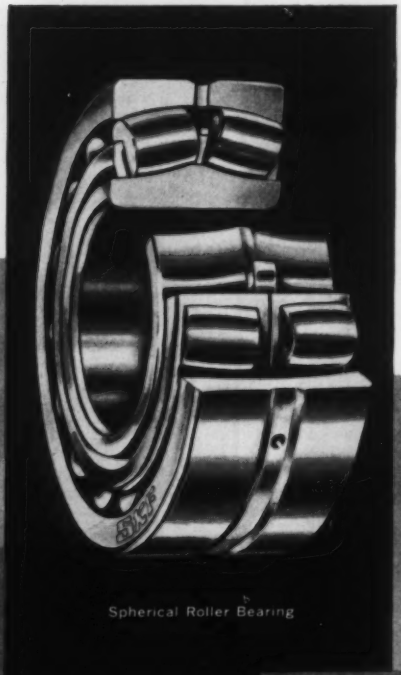
Which of these SKF bearings fits the needs of your design?

SKF continually produces all of these standard bearings—in countless sizes and variations—in production quantities. And practically all of them have exclusive features that benefit you.

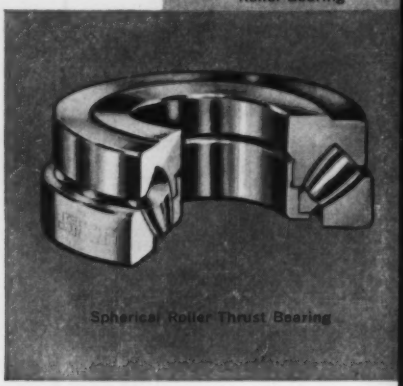
Take the spherical roller bearing, for example. Recently re-designed, it now offers 25 to 50% increased capacity and 2 to 3½ times longer service life. Yet it's a standard SKF bearing—promptly available in over 130 standard sizes ranging from 2.4" to 53.5" O.D., with every possible combination of seals, shields and adaptors to meet your specifications.

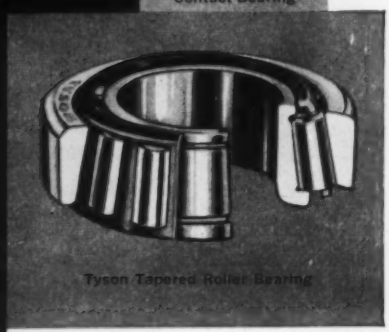
But why not get full details on this—or any other— SKF bearing? Each is made to do an efficient, economical job for you. Call any one of the 25 SKF sales offices today. 5906

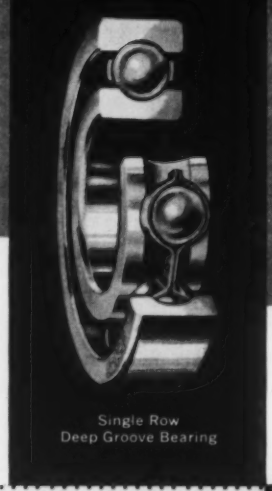

Cylindrical Roller Bearing


Spherical Roller Bearing

Angular Contact Bearing


Spherical Roller Thrust Bearing


Tyson Tapered Roller Bearing


Single Row Deep Groove Bearing

Spherical, Cylindrical, Ball, and "Tyson" Tapered Roller Bearings

EVERY TYPE EVERY USE

SKF

SKF INDUSTRIES INC., PHILADELPHIA 32, PA

® REG. U. S. PAT. OFF.

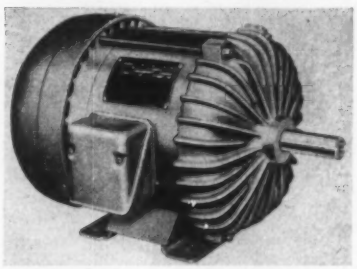
cluding missile systems, underwater sounding, level indicators, sound reproduction, telemetering, and airborne sensing circuits. Upper Curie temperature is 150 C. Unit is available in all sizes and shapes required in ultrasonic industry. **U. S. Sonics Corp.**, 625 McGrath Highway, Somerville, Mass. B

Circle 728 on Page 19

Single-Phase Motors

with ratings from 3/4 to 5 hp

Totally enclosed, explosionproof motors are available in two, four, and six-pole speeds, and are built in rerated NEMA frames 182, 184, 213, and 215. Ratings range from ¾ to 5 hp. Condensers and



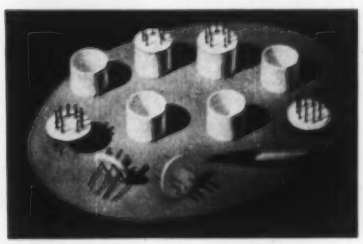
centrifugal mechanism are completely enclosed within front-end head, providing added protection and cleaner over-all appearance. Motors are designed for installation in any environment. **Motor Div., Robbins & Myers Inc.**, Springfield, Ohio. G

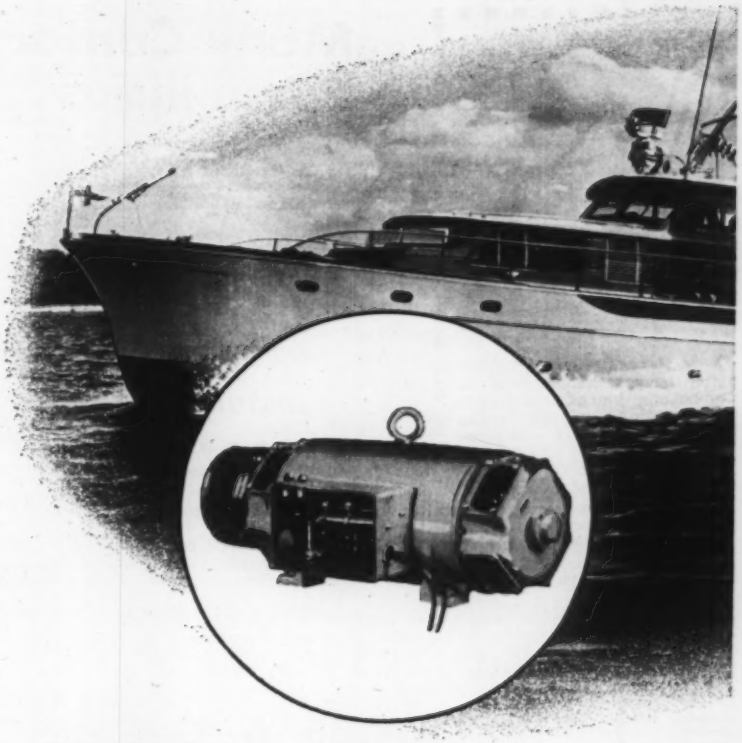
Circle 729 on Page 19

Hermetically Sealed Headers

allow high bake-out temperatures

Seven and nine-pin headers consist of tantalum pins with nickel-braze alloy, combined in a strong hermetic seal with alumina ceramic base and envelope for vacuum-tube use. Headers allow high bake-out tem-





ESCO alternator powers new ultra-compact high-performance radar

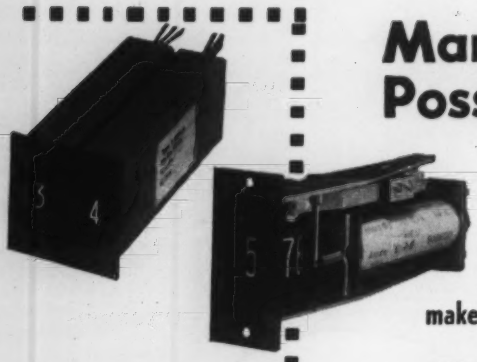
Based on an entirely new concept in radar design, this Raytheon "Mariners Pathfinder" radar is compact enough for use on the most modest pleasure cruiser, yet big enough in performance for the largest commercial vessels. Utilizing just two, simple units, it provides clear, steady displays up to 16 miles range. Rugged and reliable, it's real sea-going equipment, built to operate in slashing northeasters, arctic ice and the heat and humidity of tropic seas.

To provide a source of dependable, stable power for the "Mariners Pathfinder", Raytheon chose a specially-designed ESCO motor-alternator. Operating from a 32V, 110V or 220V DC ship's supply, this built-to-order inverter delivers a 115V 60-cycle AC output, regulated to ±3V and ±0.6 cycles over a 20% variation in input voltage. It's designed for a minimum of 10,000 hours trouble-free operation under extremely wide variations in temperature, humidity, and pitch and roll conditions.

Building special rotating electrical equipment to meet individual requirements has been a specialty at ESCO for almost half a century. Why not call on ESCO for the ideal generator or motor for your equipment, too? *Write for design brochure today.*

ESCO ELECTRIC SPECIALTY CO.
179 South Street, Stamford, Conn.

Circle 543 on Page 19



Many Contact Possibilities . . .

make SODECO's 1TD *an extremely useful impulse counter*

A variety of contact possibilities at either 0 or 9, or both, either normally open or normally closed, make SODECO's 1TD impulse counter a useful tool for the design engineer. These single decade counters, available in either adding or subtracting models, can solve such problems as:

1. Any number may be installed in series to form a multi-digit counter.
2. Addition or subtraction with remote zero reset.
3. Transmission of numbers to a remote location with or without zero reset.
4. Remote predetermining by dial or punched cards, with contact operation at zero, with the possibility of recycling to an originally predetermined number.

SODECO 1TD ten or twenty-five impulse/sec. counters are compact (⅞" x 1¾" x 4⅜"), rugged units suitable for flush mounting. The large, easy to read numbers are 5/32" wide and 13/32" high. Power requirements are low—permitting their installation in electronic circuits. Their cost is reasonable, too.

Complete technical data is available, including circuitry recommended for a wide range of use. Write for Bulletin E-19 and E-44a.

LANDIS & GYR, INC.

45 West 45th Street, New York 36, New York

Circle 544 on Page 19

Let

NATIONAL RETAINING RINGS

simplify your designs!

TYPICAL APPLICATION

National Retaining Rings improve design of this electronic coupling. Assembly is faster, easier—saves time and money.

ENGINEERING ASSISTANCE

Send drawings or sample parts for suggestions on your specific design problems or write for illustrated literature on these cost-cutting retaining rings.

National Retaining Rings have effected important economies in a wide range of applications from heavy duty machinery to toys. Elimination of machining, threading, nuts and cotter pins are typical advantages. In many applications, reduced space and weight requirements and substantial savings in material can be accomplished with these easy-to-install retaining rings.

The NATIONAL LOCK WASHER COMPANY

Serving Industry Since 1886

NEWARK 5, NEW JERSEY • MILWAUKEE 2, WISCONSIN

Circle 545 on Page 19

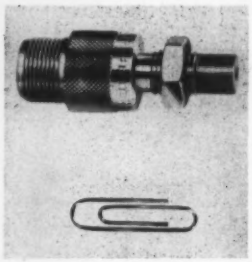
peratures during subsequent assembly to envelope. Materials have low vapor pressure characteristics. **American Lava Corp.**, Manufacturers Road, Chattanooga 5, Tenn. A

Circle 730 on Page 19

Proximity Pickup

miniature unit detects parts with diam of less than 0.1 in.

Model 4912-AN pickup has sensing face of ⅜ in. diam, over-all length of 2⅛ in., and mounting thread of 7/16-20. Probe-type pickup detects both ferrous and nonferrous metal parts having a diam of less than 0.1 in., and can be excited by gear teeth of 10 diametral pitch. Unit detects stationary



metal objects as well as moving metal pieces passing pickup at a rate to 60,000 per min. High-temperature range is up to 200 F, and low-temperature range is apparently unlimited. **Electro Products Laboratories**, 4500 N. Ravenswood Ave., Chicago 40, Ill. I

Circle 731 on Page 19

Composite Metal

offers clad strip advantages in low-cost material

Thermo-Lay strip is a hard, dense layer of metal electrolytically deposited, then heat treated to achieve a metallurgical bond to a base-metal strip, and finally rolled to finished thickness and temper. Surface layer is rolled to same temper as required in base metal. Overlay metals include silver, nickel, copper, tin, zinc, gold, cadmium, and solder combinations. They are bonded to copper, brass, nickel, cupronickel, steel, and bronze. Maximum width for most combinations is 7 in., with a few up to 10 in.; minimum width is 1/16 in. Maximum plating thickness is 0.005 in. per side, with minimum of 0.0001 in. Over-all thick-

here's a 3-POINT PROGRAM for lower cylinder costs

Cut inventory costs

to a minimum by taking advantage of fast deliveries from Hydro-Line factory stocks. Over 90% of all cylinder applications fall into the thousands of bore, stroke and cushion combinations ready for immediate shipment. Series R2 cylinders rated at 200 psi air and 500-2500 psi hydraulic; Series S2 cylinders rated at 200 psi air and 1000 psi hydraulic; Series N cylinders rated at 2000 psi and higher.

Pare maintenance costs

by taking advantage of the cylinders that not only require fewer downtime periods in every class of service, but also are faster and easier to service on the job without special tools or equipment.

Save 42-1/2% by specifying R2 Series

Specifying this design instead of high-pressure hydraulic cylinders will give you these, or even greater, savings. You can save even more by specifying stock cylinders. By choosing Hydro-Line you can eliminate specials on almost all jobs. All three series — R2, N, and S2 — meet J I C specifications.

Just fill in the coupon below to get bulletins containing more data or contact your nearby Hydro-Line representative.

act now!

Please send me additional data on the classes of Hydro-Line cylinders checked below, including complete information on deliveries from factory stocks:

( ) Series R2 (heavy-duty air, medium-duty hydraulic, industry standard)
( ) Series N (heavy-duty hydraulic, industry standard)
( ) Series S2 (automotive industry automation standards)

Name and Title _____
Company _____
City _____ State _____

HYDRO-LINE MANUFACTURING COMPANY
5602 PIKE ROAD ROCKFORD, ILLINOIS

HL HYDRO-LINE CYLINDERS

5602 PIKE ROAD • ROCKFORD, ILLINOIS

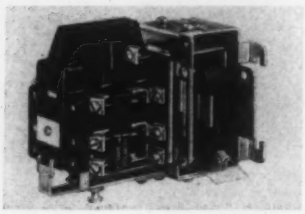
manufacturers of: high- and low-pressure hydraulic cylinders • heavy-duty air cylinders • adjustable-stroke cylinders • dispensing cylinders • intensifiers • single-acting cylinders • booster cylinders

ness ranges from 0.125 to 0.001 in. Strip is supplied with overlay on one or both sides, either with equal thickness on each side or to any desired specification. Metal is employed whenever good corrosion resistance or electrical properties are required. Applications include contact wiping arms, switches, contact points and springs, flexible wave guides, terminals, and tuners. **American Silver Co.**, 36-07 Prince St., Flushing 54, N.Y. D

Circle 732 on Page 19

Control Relays

mechanically held units are rated at 10 amp, 600 v



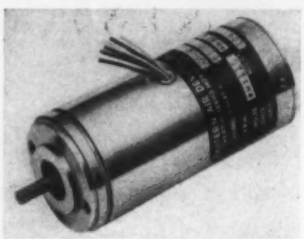
Type D mechanically held relays mount in the same panel space as electrically held units, eliminating the need for mounting mechanically held relays separately. The relays, rated at 10 amp, 600 v, are available in a variety of units up to ten contacts. **Square D Co.**, 4041 N. Richards St., Milwaukee 12, Wis. K

Circle 733 on Page 19

Servomotor

incorporates an inertial damper

High-performance servomotor incorporates an inertial damper within size 10, 11, or 15 frame. Unit is electrically equivalent to lead-lag network used in servomechanism applications. Inertial damper within servomotor provides maximum velocity constants, line frequency



EVERY TYPE OF CUT GEAR FOR EVERY INDUSTRIAL PURPOSE

SINCE 1888... We have been making many types and sizes of gears for industry. During these passing years we have derived considerable experience, trained numerous personnel, and expanded our mechanical and plant facilities—and have remained under one continuous management. We are ready to ably serve you.

ESTABLISHED 1888

D.O.James

D. O. JAMES GEAR MANUFACTURING CO.
1140 W. Monroe Street, Chicago 7, Ill.

Circle 547 on Page 19

HYDRAULIC EQUIPMENT WORKS BETTER with FERROFILTER

Magnetic Separators on the job

Low Pressure FERROFILTERS

1" and under made this way
Other low pressure models to 3" pipe sizes
High Pressure Models Also Available

NO MORE RUST AND SCALE

with FERROFILTERS in fluid power systems. These magnetic separators keep ferrous particles from circulating and building up . . . help prevent scoring, scratching, sticking and non-functioning of valves, pumps and other precision parts which are sensitive to fine particles of metal and rust.

Write for more complete information contained in our

BULLETIN PM-83

S. G. FRANTZ CO., Inc.

Brunswick Pike and Kline Ave.

P. O. Box 1138 Trenton 6, N. J.

Circle 548 on Page 19

... CONTINUOUS PROCESSING -- 1960 ...

CAMBRIDGE METAL-MESH BELTS help you beat *today's* profit squeeze—give you the low-cost production and high product quality needed for the *competitive '60's!*

Combined movement and processing means metal parts, foods, ceramics or chemicals are processed faster, more uniformly—without costly manual handling. High product quality is maintained because heat, cold or liquids flow through the belt and around the product for thorough treatment. Cambridge Belts save on operating costs, too. Superior belt design and manufacturing techniques mean longer life, fewer repairs, lower operating costs. Belts can be made heatproof, coldproof or acidproof—in any mesh, weave, metal or alloy—with any side or surface attachments.

Whether you're designing machinery for your own use, or for resale, the Cambridge Field Engineer in your area will be glad to discuss the many advantages of Cambridge Belts—from the manufacturing end to installation and service. Call him today. He's listed in the yellow pages under "Belting, Mechanical". Or, write for FREE 130-PAGE REFERENCE MANUAL.

The Cambridge Wire Cloth Co.

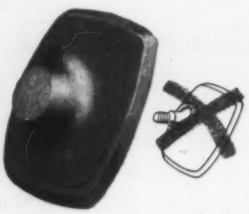
DEPARTMENT N • CAMBRIDGE 2, MARYLAND

Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications

REDUCE MANUFACTURING COSTS
IMPROVE PRODUCT PERFORMANCE
SOLVE DESIGN PROBLEMS
with
WORLD BESTOS
MOLDED ORGANIC PARTS

REDUCE COSTS
High-density molded organic part replaces brass pressure plate in clutch assembly

IMPROVE PERFORMANCE
Semi-flexible molded organic parts replace leather washers in deep well pump



SOLVE DESIGN PROBLEMS
Resilient molded organic part replaces combination metal-hard rubber vibration damper

● A fresh approach to design problems with WORLD BESTOS Molded Organic Parts can pay off in improved product performance and reduced manufacturing costs. Applications range from industrial and automotive equipment to home appliances. Molded Organic Parts can be built to meet virtually any shape, size or performance specifications. Parts can be supplied for testing and evaluation or on a production basis. For complete details, send samples or blueprints to WORLD BESTOS, New Castle, Indiana. Phone Jackson 9-4790.

WORLD BESTOS NEW CASTLE INDIANA

DIVISION OF THE Firestone TIRE AND RUBBER CO.

Industrial and Automotive Brake Blocks and Linings • Transmission Linings • Special Clutch Facings • Vibration Controls • Sheet Packing

COPYRIGHT, 1959—WORLD BESTOS

Circle 550 on Page 19

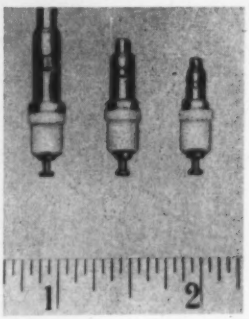
insensitivity, no wiring or pickup problems, suppression of residual noise, noncritical adjustments, and no loss in shaft output. Unit meets military specifications and operates to 150 C. **Eastern Air Devices Inc.**, 385 Central Ave., Dover, N.H. B

Circle 734 on Page 19

Diode Clips

spring-loaded units are Teflon insulated

Three spring-loaded diode clips are feed-through types designed to press-mount into 0.205-in. diam holes in terminal boards. Teflon insulation overlaps at top and bottom, securely mounting clip while



insulating it. No. 2424 clip accommodates diodes with wire leads to 0.04 in. diam, No. 2422 to 0.055 in. diam, and No. 2405 to 0.085 in. diam. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass. B

Circle 735 on Page 19

Self-Adhesive Foam

lightweight plastic material has excellent damping quality

Air-O-Seal is a pressure-sensitive, polyurethane plastic foam that adheres to any surface after removal of backing sheet. With a weight about one-third that of rubber, it has excellent resiliency with minimum compression set. Insulation properties are nearly twice those of cork. Superior damping quality minimizes influence of vibration, reduces shock, and eliminates rattle. Material is highly resistant to temperature extremes and has excellent sound-deadening characteristics. Chemically inert, it possesses a neutral reaction, resists corrosive attacks, and is fungus, mildew, and

termiteproof. Foam is impervious to water, resists oils and most chemicals. It is available in varying thicknesses, assorted sizes and colors, and numerous die-cut patterns to specifications, as well as standard rolls, blocks, or sheets. **Air-O-Plastic Corp.**, 310 Seventeenth St., Union City, N. J. D

Circle 736 on Page 19

Differential Transformers

for linear displacement from ± 0.5 to ± 8 in.

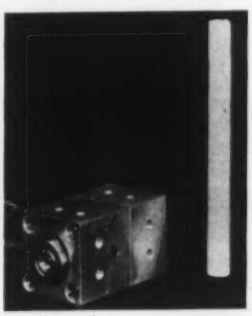
High output and low impedance secondary windings are features of small differential transformers of which linear stroke is 70 per cent of coil length. Units are for linear displacement from ± 0.5 to ± 8 in. Ratio of output voltage, at range limit, to null voltage is 1000:1. Linearity of ± 0.5 per cent over a temperature range of − 60 to 250 F is attainable. Transducers are magnetically shielded, potted, and furnished with Teflon-insulated leads. **Automatic Timing & Controls Inc.** Dept. 213, King of Prussia, Pa. E

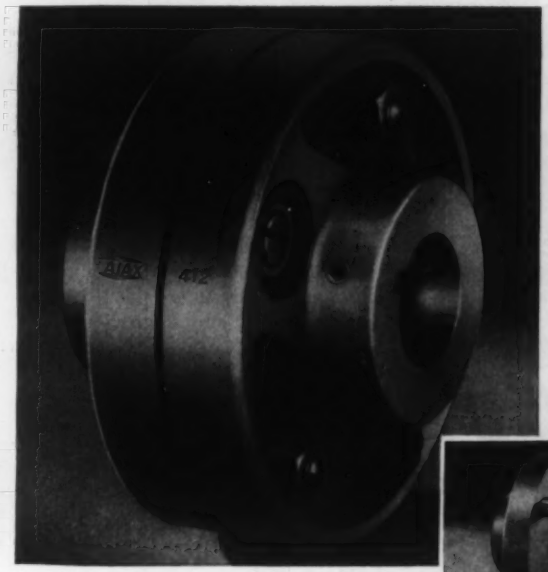
Circle 737 on Page 19

Acceleration Switch

senses positive and negative acceleration

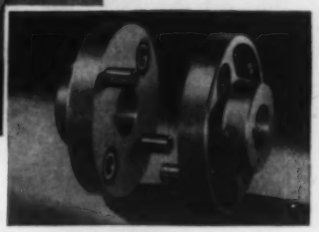
Applicable in missiles, aircraft undercarriages, and in shock testing of electronic equipment, acceleration-sensitive switch is continuously adjustable for sensitivity to positive and negative acceleration along a single axis. Seismic mass drives an element with two stable posi-





Left: Periphery and face of Series 400 flanges are machined to simplify lining up with straight edge or feeler gauge.

Below: Separated halves show arrangement of 4 drive studs and rubber cushioned sleeve bearings.



AJAX ANNOUNCES

NEW *Series 400*

Normal Duty Flexible Couplings

at New Low Cost

● Original equipment manufacturers and plant engineers can now have the protection of AJAX positive resilient drive for direct-connected machines at minimum cost.

New AJAX Series 400 rubber cushioned flexible couplings are particularly suited to connect motors directly to pumps, fans, mixers, speed reducers, light duty hoists, compressors, and other machines with average torques in relation to shaft diameters.

The performance of new AJAX Series 400 Couplings is based on the same proven design which has been giving satisfaction in hundreds of thousands of installations for 40 years.

Their 4 steel studs and sleeve bearings require no lubrication. Rubber cushions absorb unavoidable misalignment, and their resiliency provides a quiet cushioned drive in both directions of rotation.

AJAX Series 400 Flexible Couplings are made in 4 sizes with 1¼", 1¾", 2¼", and 2¾" maximum bore respectively with standard square keys.

Mail coupon for Catalog 67.

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
102 Portage Road, Westfield, N. Y.
Send Catalog 67 on Series 400 Couplings.

Name_____

Concern_____

Address_____

Circle 551 on Page 19

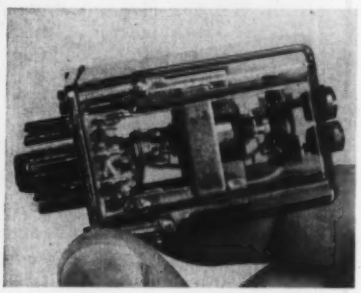
tions. Adjusting screws bias the element to provide variable sensitivity. In standard model illustrated, sensitivity is adjustable over ± 30 g and is nonadjustable outside this range. Acceleration being sensed serves only to trigger the element, which then uses stored energy to complete switching operation. Result is short contact-travel time and high sensitivity. Basic design can be produced in various configurations and with pressurization, hermetic sealing, damping, and other features. Weight of unit is 5 oz. **Eastern Technical Associates Inc.**, 31 Sudbury Rd., Concord, Mass. B

Circle 738 on Page 19

Meter-Relay

nonindicating type
resists shock and vibration

Model 137 offers advantages of a standard locking-coil meter-relay except dial indication and is more resistant to shock and vibration. It incorporates adjustable contacts,



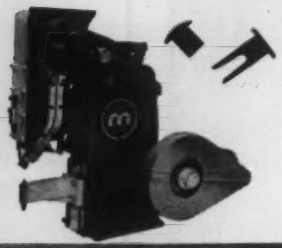
permitting easy changing of either control points or calibration. Clear plastic case is only 2 in. long and 1⅜ in. square. Total length, including the nine-pin plug-in base, is 2½ in. Unit triggers control action on signal changes as small as 0.2 mu amp or 0.1 mv dc. **Assembly Products Inc.**, Wilson Mills Rd., Chesterland, Ohio. F

Circle 739 on Page 19

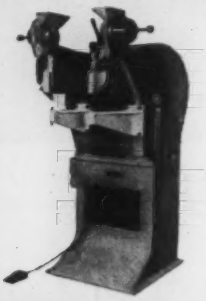
Pushbutton Station

has waterproof, noncorrosive, lightweight construction

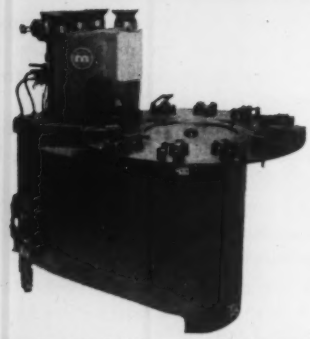
Available in either three or four-button models, pushbutton station with neoprene housing features waterproof, noncorrosive, lightweight construction. Two-piece housing



CUT RIVET ASSEMBLY COSTS



with Milford's Complete Line of AUTOMATIC RIVETERS



Can be adapted to solve nearly every fastening and assembly problem. For the answers to assembly problems... *get in touch with Milford first!*

THE MILFORD RIVET & MACHINE CO.

MILFORD, CONNECTICUT • HATBORO, PENNA.
ELYRIA, OHIO • AURORA, ILL. • NORWALK, CALIF.

Circle 552 on Page 19

Only Pennies Per Part

only the new Minicast High Production Process gives you miniature parts with

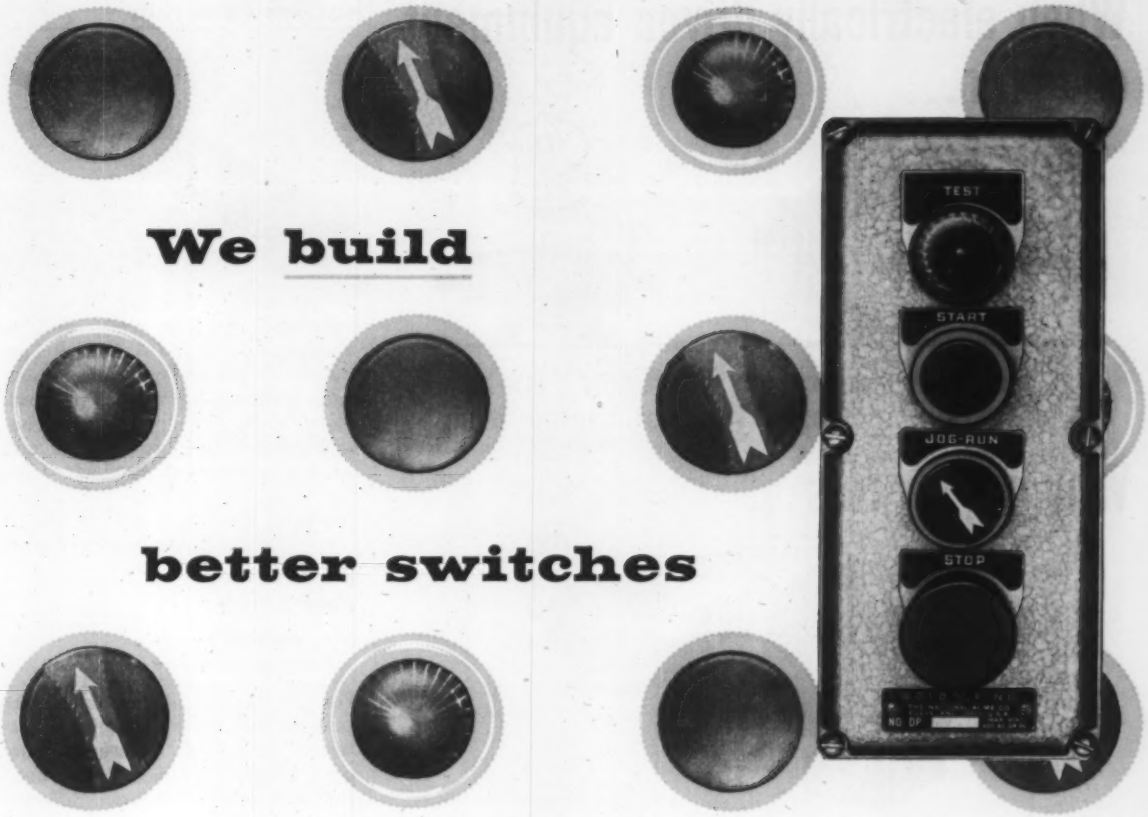
- dimensional tolerances as close as plus/minus 0.001"
- cross sectional thicknesses as low as 0.020
- exceptional surface finish as low as 30 to 50 microinches
- complex configurations
- metal parts in nearly all castable metals and alloys
- unbelievably low unit cost with high production runs

Get the complete story . . . Write for this new descriptive brochure . . . it's free of course

Casting Engineers INC.

2321 NORTH BOSWORTH AVENUE
CHICAGO 14, ILLINOIS

Circle 553 on Page 19



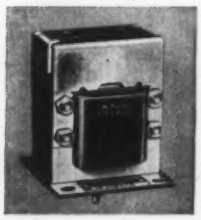
We build better switches because we can't buy them

...IT'S AS SIMPLE AS THAT...AND THEY COST NO MORE THAN OTHER SWITCHES

We had to build Gold-N-Ring Control Switches to meet our own high reliability specifications . . . our reputation was a part of this important fact. We're machine tool builders. We can't afford to be responsible for costly down-time on important capital investment equipment due to inferior control switches. That's why we build them like precise machine tools . . . and why it will pay you to check with us.

A wide range of basic units meets practically every need . . . as well as completely assembled stations in 1 to 4 button sizes to meet your electrical specifications. Ask our representative to call, or send for Bulletin ECS-56 . . . the complete selection and ordering guide.

LIMIT SWITCHES. A full line, originally designed for machine tool applications but now used wherever the highest reliability factors are required. Bulletin EM-51.



SOLENOIDS. A full line of standard and custom units for AC or DC. Push or pull types with capacities up to 25 lbs. Bulletin EM-52A.

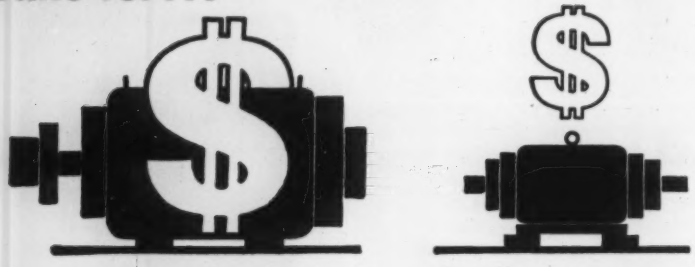
ELECTRICAL MANUFACTURING DIVISION

National Acme

THE NATIONAL
ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Circle 554 on Page 19

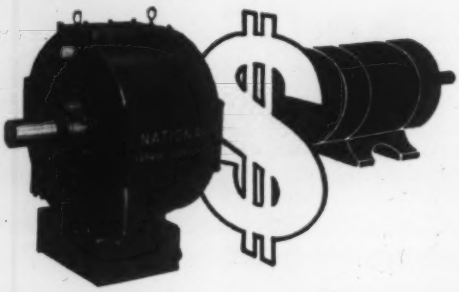
When electrically driven equipment calls for...



a special, costlier motor to start things

but only a low-cost motor to run them

Why not try this...



A NATIONAL Torque Converter to give high starting torque

with your cost-saving motor to keep things moving

NATIONAL® Torque Converters give you "big motor" torque from small motor investment

Like a car in heavy traffic, the work-cycle of a lot of heavy, electrically-driven equipment is stop-and-go, stop-and-go.

If the motor is selected to take care of *running* requirements, it won't have the starting torque needed to pick up heavy loading fast. If the motor is selected for *starting* requirements, it is likely to cost considerably more—both to buy and to run.

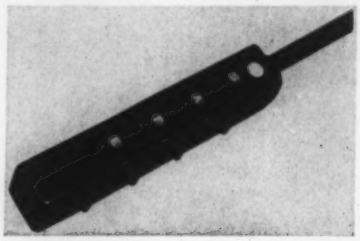
The best answer is to install the more economical motor—and let it drive through a NATIONAL Torque Converter. The converter will multiply the motor's torque for picking up the loads, ease the shocks and stresses of operation, bring economy in first cost and day-to-day service. NATIONAL Torque Converters are available in a range of capacities from 100 to 1000 HP. For detailed technical information, write:

THE NATIONAL SUPPLY COMPANY

Subsidiary of Armco Steel Corporation

TWO GATEWAY CENTER, PITTSBURGH, PA.

Circle 556 on Page 19



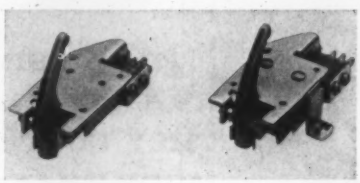
weighs only a fraction of a conventional cast-iron unit, and is about one-third the size. Each button is an integral part of housing and, with continuous design, completely encloses snap-acting switches and protects them from water and weather. **Electrical Products Div., Joy Mfg. Co.**, Dept. P-45, 1201 Macklind Ave., St. Louis 10, Mo. I

Circle 740 on Page 19

Hook Switch

is actuated by hanging accessory on circuit

For use where it is desirable to actuate a switch by hanging an accessory on a hook, such as hanging up a head set or microphone, hook switch is provided for two different types of mounting. Series 14000 (left) mounts by frame, and Series B14000 (right) has bracket for mounting on panel behind switch. Switch requires minimum depth be-



hind panel. Relatively long springs without forms at point of flexing insure suitable spring action for long life. **Switchcraft Inc.**, 5555 N. Elston Ave., Chicago 30, Ill. I

Circle 741 on Page 19

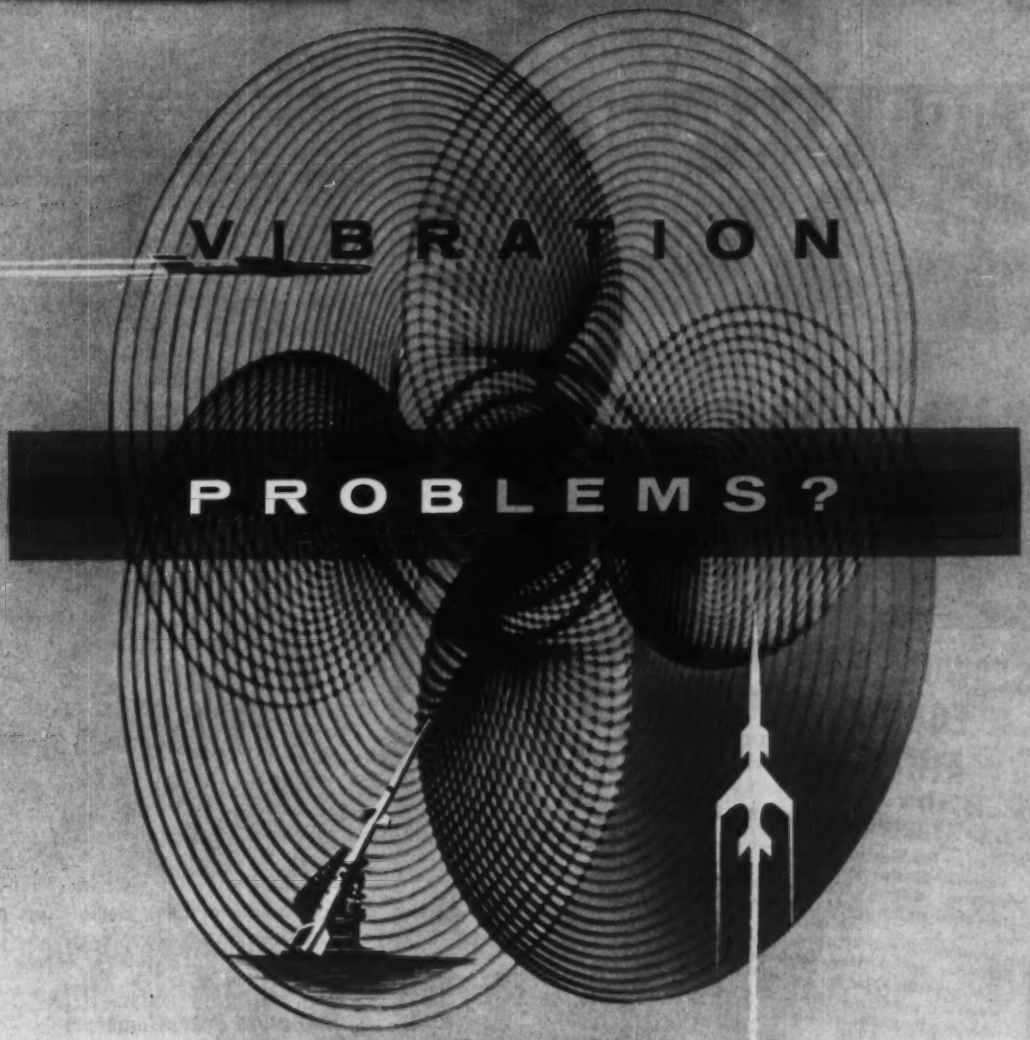
Alloy-Junction Transistor

provides good frequency response

No. 2N647 transistor of germanium n-p-n type is intended for use along with a p-n-p counterpart in class B complementary-symmetry power output stages of transformerless, battery-operated portable radio receivers, phonographs, and audio

Circle 557 on Page 19→

VIBRATION PROBLEMS?



CALL OUT CANNON PLUGS

Improvements are constantly being made in Cannon connectors to give you maximum reliability in circuitry under constantly increasing highly critical vibration conditions. New lines... improvements on the MS-E design... include the EX, the CT, the EA, and the EB Series.

You'll find Cannon vibration and moisture-proof resilient-insert lines extensive and complete, in hundreds of carefully designed layouts. Interfacial sealing. Improved grommets and grommet followers. Styles with extra strong coupling nuts. Telescoping rubber bushings. Strong clamps. Means for safety wiring. Grounding lugs. Every facility to give solutions to vibration, moisture condensation, flashover, and corona problems.

Vibration-proof Series include MS-E, CA-F, EA, EB, EX, and CT. Write TODAY for full information.

MS-E (Series CT)
Socket Assembly
Ask for
MS-E Catalog

CA 3100 F
Wall Mounting Receptacle
Ask for
AN/MS Catalog

MS-E (Series ME)
63 Inserts Available
Ask for
MS-E Catalog

EX 06
Plug Assembly
Ask for
EX Catalog

Write for 44-page, 2-color Plug Guide, Bulletin CPG-2

CANNON PLUGS
WHERE RELIABILITY IS THE 5TH DIMENSION

CANNON ELECTRIC CO., 3208 Humboldt St., Los Angeles 31, Calif. Factories in Los Angeles, Salem, Mass., Toronto, Melbourne, London. Manufacturing licensees in Paris and Tokyo. Representatives and distributors in all principal cities.

15,000 hours at 55°C

without servicing or oiling

and still going strong!

Air-Marine Motors go to sea on USS Seawolf, Navy's newest atomic-powered submarine.

SEAWOLF'S VITAL ELECTRONIC EQUIPMENT COOLED BY AIR • MARINE MOTORS

15,000 TO 20,000 HOURS UNDER THE SEA!

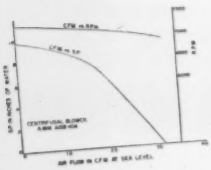
When the U.S. Navy's atomic-powered submarine—miracle of modern engineering—churns through the waters at 50 fathoms down, its vital electronic equipment is constantly protected day and night by a battery of the most rugged blowers ever devised.

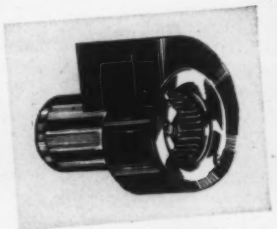
Incorporating into its design equipment never before mounted for undersea service, Navy engineers were confronted with a critical cooling problem, for the Seawolf was to stay submerged week after week and month after month. And such equipment must be dependably and constantly cooled.

Tough project? Not at all for Air-Marine. It's highly trained staff of engineers pooled their knowledge and promptly designed, to rigid Navy specifications, blowers that could run continuously toward a 10,000 hour life—more than a solid year—delivering uninterrupted cooling for the A-sub's vital installations.

Whatever your problem—small or large—this same experienced engineering staff is yours to command. Contact Air-Marine for your motor needs—for the best motors skill can produce—the finest money can buy.

115V 400CY 1PH 1.0MFD





Air-Marine's Seawolf Motor

air • marine motors, inc.

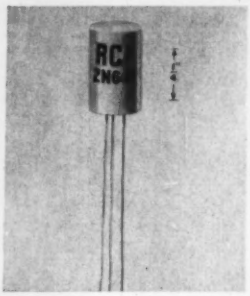
369 Bayview Avenue, Amityville, N. Y.

West Coast Factory: 2221 Barry Ave., Los Angeles, Calif.

Above is an air-marine motors advertisement which first appeared in July, 1957.

See us at the IRE Show • Booth 2315

amplifiers. It is particularly useful in equipment in which compactness, good frequency response, and relatively high power output at low cost are important design considerations. Unit can also be used in conventional class B push-pull and in class A audio-amplifier circuits. Transistor has a large-signal dc transfer ratio essentially constant over operating current range to insure circuit linearity. Collector cut-



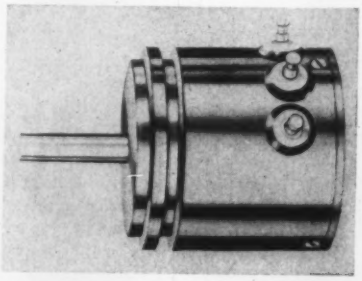
off current of 14 ma insures stable performance under varying ambient temperature, and excellent uniformity of characteristics to provide unit-to-unit interchangeability. **Semiconductor Div., Radio Corp. of America**, Somerville, N. J. D

Circle 742 on Page 19

Miniature Potentiometers

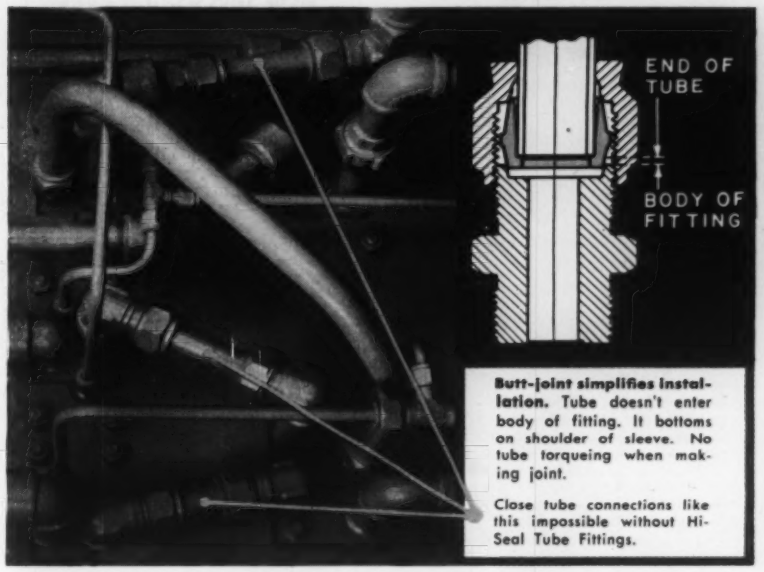
single-turn units have power rating of 1.2 w at 40 C

Redesigned series T, 7/8-in. diam potentiometers have standard resistance range from 650 to 100,000 ohms ± 5 per cent, with ± 2 per cent also available. Standard linearity tolerance is ± 0.5 per cent, with ± 0.2 available. Power rating is 1.2 w at 40 C, derating to zero at 125 C. Weighing only 0.6 oz, unit has either servo or bushing-mounting styles. Starting torque is 0.1 oz-in. maximum per section, with five ganged sections readily



IMPERIAL Engineering and Data File

ENGINEERED TUBE FITTINGS — VALVES — TUBING TOOLS



Butt-joint simplifies installation. Tube doesn't enter body of fitting. It bottoms on shoulder of sleeve. No tube torqueing when making joint.

Close tube connections like this impossible without Hi-Seal Tube Fittings.

Far more compact hydraulic piping layout made possible by Hi-Seal butt-joint tube fittings

This hydraulic power unit built by Scott Equipment Company, Dayton, Ohio, shows how Hi-Seal flareless tube fittings create new piping design opportunities.

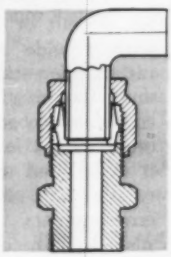
Because of Hi-Seal's *positive butt-joint feature* which requires no tube entry into fitting, Imperial Hi-Seal makes possible far more compact piping layouts than would be obtained with other fittings. In addition the butt-joint design eliminates the need to spring tubing . . . a big advantage when working with large-diameter, heavy-wall or hard-temper tubing.

Important, too, there is only one way to put the Hi-Seal fitting together. No chance of sleeve being put in backward. And Hi-Seal fittings can be disconnected and reconnected as often as desired with assurance of original pressure-tight seal! It's the ideal fitting for hydraulic and other services where higher pressures are encountered. Meets J.I.C. and A.S.M.E. Standards. Available in Steel, Stainless Steel and Brass.

Write for Bulletin No. 3061

• • • • • •

Limited space no problem for Hi-Seal fittings

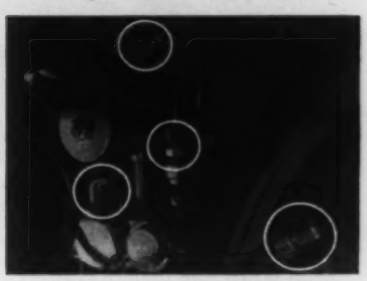


Because no flaring is necessary, and because of its butt joint, this fitting permits bends to be made exceptionally close to the end of the tubing . . . a major design advantage where space is limited.

IMPERIAL

THE IMPERIAL BRASS MFG. CO.
6300 W. Howard St., Chicago 48, Illinois
In Canada: 18 Hook Ave., Toronto, Ontario

Make huge time and labor savings with Poly-Flo tube fittings



New Lindsay All-Automatic Water Softeners employ Imperial Poly-Flo tube fittings and polyethylene tubing in the saturated brine lines in recharging these water softeners.

It is in units like this that Imperial Poly-Flo fittings make possible big savings in time and money. Polyethylene tubing bends readily by hand. No mechanical flaring or bending. Fittings need only be finger-tightened. Wrenches or other tools are never necessary.

Imperial Poly-Flo tube fittings hold burst pressure of polyethylene tubing and are ideal for applications involving conduction of most types of gases and liquids.

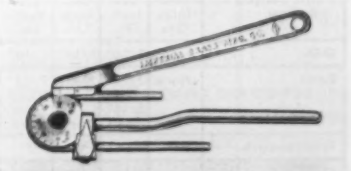
Write for Bulletin No. 3025

• • • • • •

Tube Bender for hard or soft tubing

Bend hard and soft drawn copper, steel, aluminum, thinwall conduit; even stainless steel tubing. Won't mar or flatten tubing. Calibrated for bending any angle to 180°. Sizes for ⅛" to ⅞" O. D. Tubing.

Write for Bulletin No. 3088



CONTACT YOUR INDUSTRIAL DISTRIBUTOR OR WRITE TO:

THE IMPERIAL BRASS MFG. CO.
Dept. MD-29, 6300 W. Howard St., Chicago 48, Ill.
Please rush me:
Bulletins ☐ No. 3061 ☐ No. 3025 ☐ No. 3088
Name .....
Title .....
Company .....
Street .....
City ..... **Zone** ..... **State** .....

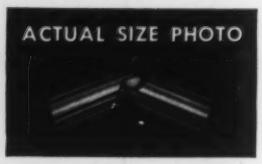
Announcing-

THE NEW
SIMPLEX

A 3/16" or larger O.D. Universal Joint featuring:

- **Minimum Static Torque Rating of 250 inch-ounces**
- **Non-magnetic stainless steel forks and bronze ball**
- **New simple 3-part design**
- **Minimum back lash**

Newest addition to the Curtis line is the Simplex, designed to fill the need for a small-size universal joint with a high Static Torque Rating. The Simplex is available in 3/16" and larger outside diameter. Made of non-magnetic material and incorporating a new design inherently strong in torque, the Simplex is particularly well adapted to electronic instrumentation.



SIMPLEX SPECIFICATIONS

Catalog Number	S3	S3B	S7	S7B
Static Torque Rating	250 Inch-Ozs.	250 Inch-Ozs.	200 Inch-Lbs.	200 Inch-Lbs.
O.D.	3/16"	3/16"	7/16"	7/16"
Bore	None	3/32" Dia. 5/16" Deep	None	7/32" Dia. 9/16" Deep
Total Length	1"	1"	2"	2"
Max. Angle of Operation	20°	20°	20°	20°

CURTIS TRADE MARK
UNIVERSAL JOINT CO., INC.
5 Bimie Ave., Springfield, Mass.
As near to you as your telephone

Circle 560 on Page 19

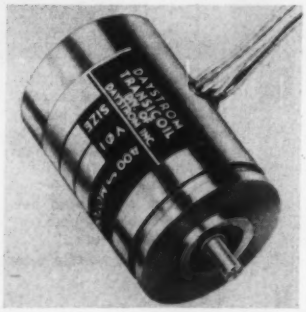
available. End play is 0.004 in. maximum, and radial play is 0.002 in. maximum. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif. L

Circle 743 on Page 19

Motor-Generator

develops stall torque of 0.3 oz-in.

Size 10 motor-generator is designed for applications where system damping is desirable. The 2.75-oz unit operates directly from transistor servo amplifiers, and develops a stall torque of 0.3 oz-in. Free speed is 6500 rpm. Generator output is 0.16 v per 1000 rpm at 10-v input, and 0.41 v per 1000 rpm at 26-v input. Maximum generator null is 36 mv, and 91 mv at inputs of 10 and 26 v respectively. **Daystrom Transicoil Div., Daystrom Inc.**, Worcester (Montgomery County), Pa. E



Circle 744 on Page 19

Rate Gyroscope

has ambient temperature range of − 65 to 165 F

GG79 gyroscope for indicating or controlling attitude rate of change for aircraft or missiles is available with a wide selection of turning rates, potentiometer resistances, and damping ratios. Unit incorporates an advanced damper and other design features which permit it to be used to detect and control rates of yaw, pitch, or roll in rugged environments. Gyroscope is furnished with one or two potentiometers, with rate switch for operating at a predetermined turning rate as optional. Unit meets all requirements of MIL-E-5272. Weighing about 1.7 lb, it occupies

PUMP DESIGN TRENDS

by Arthur A. Nichols

NEW INSERT PACKAGE REDUCES PUMP SPACE

The reliability-proved Gerotor pump has long been recognized as a space-saving unit because of its extreme flexibility of design. That's because Gerotor pump capacity is a function of diameter, thickness, number of teeth and rpm of the two moving parts. These variables can be matched to just about any space restriction and capacity requirement. Now, you can save even more space by building three simple pump components into your mechanisms with no more trouble than providing for an anti-friction bearing. *(Fig. 1.)*

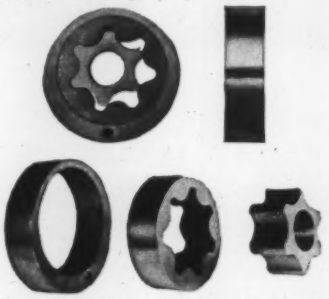


Fig. 1. Three Gerotor components permit pump to be incorporated as integral part of housing or frame of mechanism, eliminate need for purchase and mounting of separate, complete pump.

Consisting of an inner and outer Gerotor and an eccentric locator-ring, the unit becomes a complete pump by simply boring the casting or frame of the mechanism to accommodate the locator ring O.D. and by providing porting. This design makes the main casting do double duty as the pump housing, thus eliminating a very considerable cost factor. A drive can be taken from any convenient shaft.

Multiple pumping functions, such as lubricating, scavenging, boosting, etc., can be similarly built-in by mounting several "Gerotor insert-packages" and port plates on a single shaft.

These built-in Gerotor pumps are rugged, positive-displacement, valveless units capable of handling a variety of liquids at rates up to 100 gpm at pressures up to 1,000 psi. They are lightweight, high in mechanical and volumetric efficiency and are balanced and quiet in operation. Total cost, including our components and your machining and assembly is far less than what you would pay for comparable complete pumps purchased outside and mounted on your mechanism.

Investigate this concept of integral pump design. Our technical assistance is on call at all times to show you how to build these low-cost packages into your equipment. Write:

W. H. NICHOLS CO.
38 Woerd Ave., Waltham 54, Mass.

Circle 561 on Page 19

You just roll this sealer on! 3M Ribbon Sealer EC-1202

ROLL-ON RIBBON SEALER EC-1202 creates a uniform, economical, durable seal that shuts out water, dust and moisture.

It's easy to shut wind and weather out of mobile homes with 3M Sealer EC-1202. You just roll this synthetic rubber ribbon on, apply the next piece of metal . . . and fasten mechanically right through the sealer.

Because it's fabric-reinforced, EC-1202 holds its shape, doesn't stretch, sag or shrink. It applies just as easily along curved surfaces.

In mobile homes, this roll-on ribbon makes a weather-tight seal at lap seams and window beddings. And EC-1202 serves boats, curtain walls, commercial refrigeration, too. It's available in various widths and thicknesses direct from your local jobber.

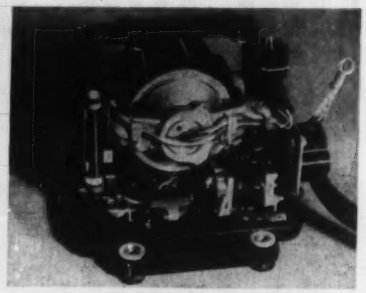
SEE WHAT 3M ADHESIVES CAN DO FOR YOU! Consult 3M Research. Contact your 3M Field Engineer. Or for information and free literature write: A.C.&S. Division, 3M, Dept. YQ-29, 900 Bush Ave., St. Paul 6, Minn.

ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

. . . WHERE RESEARCH IS THE KEY TO TOMORROW

3M COMPANY



a cube measuring about 3.5 in. Ambient temperature range is − 65 to 165 F. **Aeronautical Div., Minneapolis-Honeywell Regulator Co.**, 2753 Fourth Ave. S., Minneapolis 8, Minn. J

Circle 745 on Page 19

Phenolic Laminate

has high impact strength

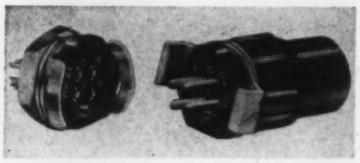
Nelco 230-R glass -reinforced XXXP laminate equals or exceeds requirements of MIL-P-3115-B, Type PBE-P grade. Capable of being cold-punched in thicknesses to 3/32 in., it is furnished plain or copper-clad. Range of thicknesses is 0.032 to 1 in., and standard sheet sizes are 36 x 42, 36 x 48, 36 x 60, and 36 x 72 in. Open-mesh glass fabric laminated into the material gives 1/16-in. laminate flatwise flexural strengths of over 18,450 psi crosswise and 14,500 psi lengthwise. Impact strength is eight time standard NEMA requirement. Water absorption for 1/16-in. thick material is less than 0.5 per cent after 24-hr immersion. **New England Laminates Co. Inc.**, 481 Canal St., Stamford, Conn. B

Circle 746 on Page 19

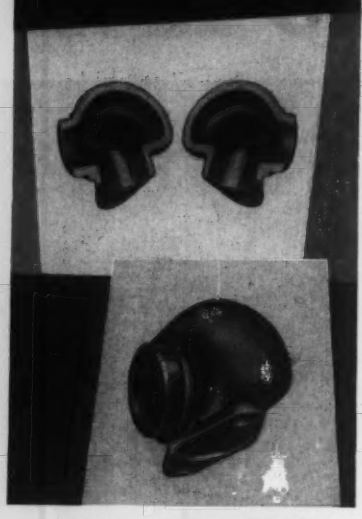
Miniature Hex Connectors

incorporate positive locking ring

Series MH miniature hex connectors with four to ten contacts are suitable for uniting cables subject to vibra-



two halves *don't* make a hole!



. . . *with* **INVESTMENT CASTING** *it's made in one piece.*

We don't tackle casting problems halfway at Hitchiner.

Here's a cross section where the inside dimensions are greater than the holes. Originally made in sections and assembled — now the whole unit is precision cast and is lighter and stronger.

Where application requirements demand that a part be of intricate shape; of unusual contour, of fine detail, or of metals difficult or impossible to machine — investment casting provides an efficient and economical solution.

Only your production costs are cut in half when you utilize the efficiency of investment casting. You save time and plenty of labor. And . . . you'll have a wide selection of metals; the non-ferrous group, the carbon and low alloy steels, the hard-to-form, hard to machine high alloy steels . . . even cobalt base alloys.

For complete details, see this new illustrated, informative booklet on the art of Investment Casting. It could be the best investment you ever made.

HITCHINER
MANUFACTURING COMPANY, INC.
MILFORD 46, NEW HAMPSHIRE
Representatives in Principal Cities

Circle 563 on Page 19

TIME
Is the only basis for
PLANNED
maintenance

Hobbs INDUSTRIAL HOUR METER

1 Encourages on-time performance of planned maintenance — for superior performance and maximum utilization of your products.

2 Sets up a sound basis for rental and leased equipment.

3 Indicates operating time in hours and minutes — at a glance.

4 A true timing instrument — not a revolution counter.

Distributors in Principal Cities
WRITE FOR CATALOG 600

FOR ALTERNATING AND DIRECT CURRENT

Hobbs a-c Hour Meter has a wide range of applications; available in 120, 240 and 480 v; 50 or 60 cps. Hobbs d-c Hour Meter indicates running time of internal combustion engines; available in 6, 12, 24, 32, 64 and 110 v.

Symbol of SW Excellence

John W. Hobbs Corporation
A DIVISION OF STEWART-WARNER CORPORATION
2962 YALE BLVD., SPRINGFIELD, ILLINOIS

Circle 564 on Page 19

YOU GET PRECISION FASTENING AT MASS PRODUCTION COSTS...

. . . when Thomson becomes your fastening partner.

In the Thomson line of more than 8,000 rivet designs, you'll find the semi-tubular, deep-drilled, bifurcated (split), shouldered or compression rivet that will give you the best strength-cost ratio in the fastening field. Produced to the industry's highest quality standards at production rates exceeding 20,000,000 rivets a day, these low-cost fasteners merit serious consideration in your product-improvement and cost-reduction programs.

Our leadership in solving fastening problems with quality rivets and precision rivet-setting machines since 1885 is at your service. What is your problem?

JTL

JUDSON L.

THOMSON

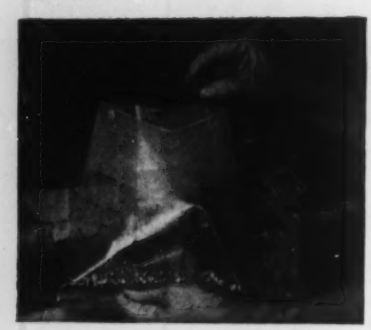
MFG. CO., WALTHAM 54, MASS.

Circle 565 on Page 19

LOCTITE cuts rejects from 13% to 1/2% on Hamilton Standard Jet Fuel Controls!

The aluminum casting of this Hamilton Standard Jet Fuel Control contains 28 pipe plugs. The assembly is subjected to hydrostatic tests with JP-4 fuel at 1500 psi. With older type sealants, only one plug in 200 leaked—but that was far from good enough for Hamilton Standard. With 28 plugs in a casting, the reject rate on the test stand was 13%. Switching to LOCTITE Liquid Sealant, they have experienced only 23 leakers in over 124,000 plugs tested . . . a reject rate of ½%.

LOCTITE is a thin liquid which hardens when confined between closely-fitted metal parts and locks against vibration. It forms a tough, heat and oil-resistant bond completely filling the joint to insure a positive seal. Hardened LOCTITE is not affected by water, military fuels, hydraulic fluids, degreasing solvents and most chemicals. It has been successfully used to seal against Co_2, oxygen, Freon, nitrogen, acetylene and LPG. LOCTITE contains no solid particles and any excess outside the joint may be wiped off . . . there is no danger of residue entering fluid stream and fouling valve seats.



At Hamilton Standard, division of United Aircraft Corp., the plugs are first cleaned by dipping in activated solvent and air dried. A day's supply of clean plugs is treated with LOCTITE by tumbling in a plastic bag. The treated parts store until used in assembly since LOCTITE hardens only when confined.

Write for literature and free sample.

LOCTITE® SEALANT

AMERICAN SEALANTS COMPANY

111 Woodbine St., Hartford 6. Conn.

In Canada: J. S. Parkes & Co., Ltd., Montreal

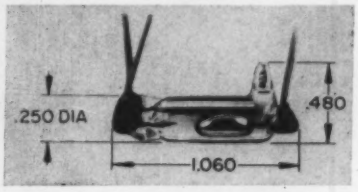
Circle 566 on Page 19

tion, pull, or other in-use stresses. The electrical connectors incorporate a positive locking ring. U. S. Components Inc., 454 E. 148th St., New York 55, N. Y. D

Circle 747 on Page 19

Mercury Switch

has differential angle of 0.15 deg maximum



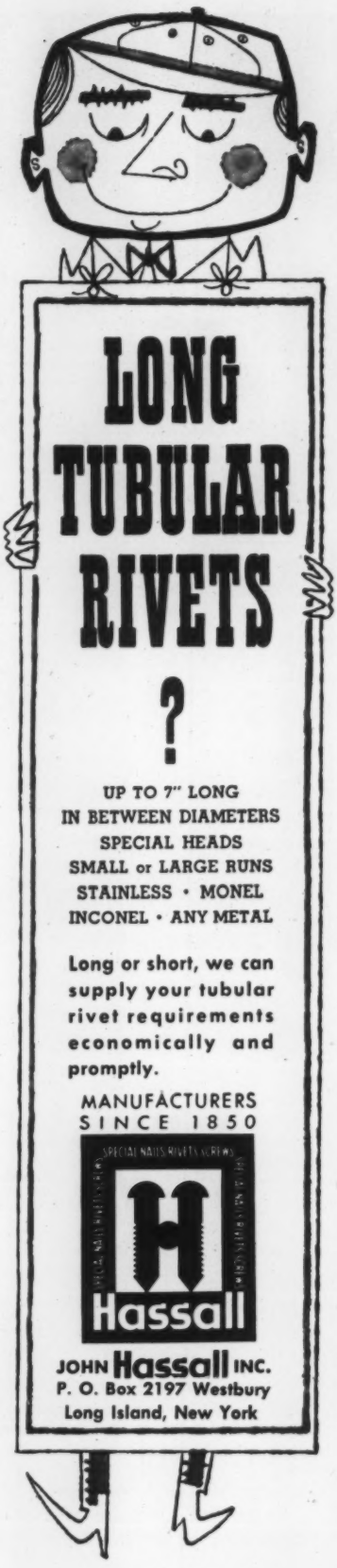
Designated AS6003AI, low-angle switch meets requirements of vertical gyros, stable platforms, and rocket-guidance systems. Switch weighs only 3.8 grams, including three 7-in. Teflon-insulated leads. It features a differential angle of 0.15 deg maximum and mass shift of 0.085 gm-cm. Hermetic sealing of glass tube prevents dust, dirt, and corrosive vapors from fouling contacts. Contact arrangement is single pole, double throw. Switch is electrically rated for 0.255 amp maximum, 30 v ac, 400 cps, for an inductive load. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill. K

Circle 748 on Page 19

Shaded-Pole Motors

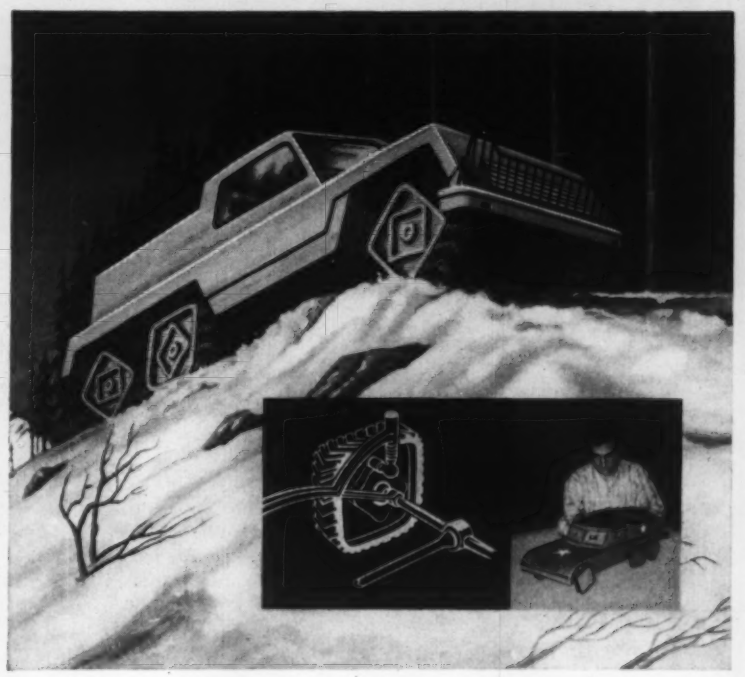
have integral stator core insulation

KSP-29 motors with 5-in. diam are rated up through ⅛ hp and are available in both four and six-pole models. They incorporate integral stator core insulation which has excellent dielectric strength, especially under moisture conditions. Motor is designed especially for use on window fans and on portable



Circle 567 on Page 19

No. 14 • Mars Outstanding Design Series

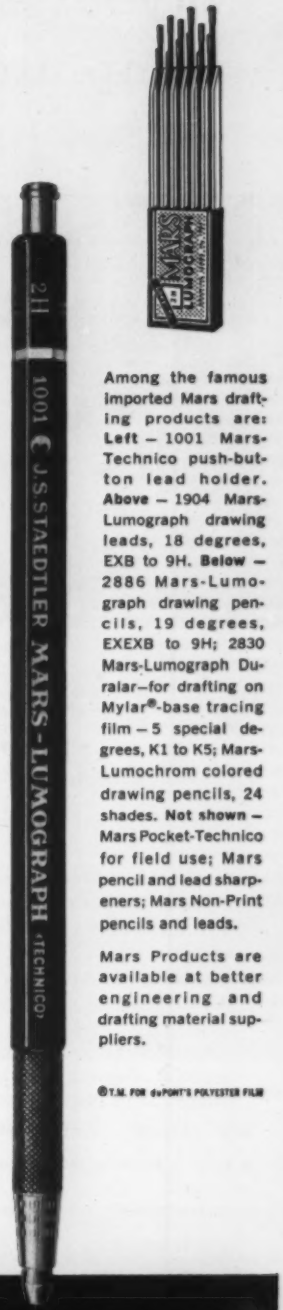


SQUARE WHEELS? Yes ... square wheels. Operating by means of a floating axle and cam gear, they take the bumps out of rough terrain and provide more traction. U.S. Patent No. 2786540 has been granted to designer Albert Sfredda of Bethlehem, Pa., for his invention.

The square shape gives superior traction in mud, sand, snow or uneven terrain. The flat surfaces of the wheels bridge the ruts instead of sinking into them as do round wheels. The wheels can be in any relative position, do not need to be synchronized—yet they run smoothly. Designed for use on heavy trucks, jeeps, farm or construction machinery, speeds up to 35 miles per hour can be attained.

This ingenious departure from age-old precedent is just one example of the contributions that today's designers are making. To help them translate their pace-setting ideas from concept to reality they require the best of drafting tools.

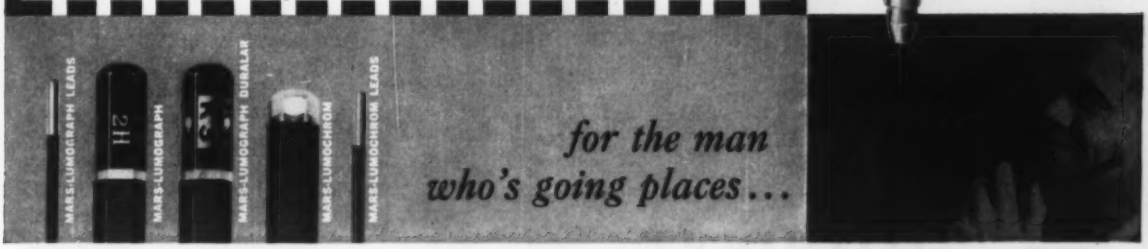
In pencils that means MARS, long the standard of professionals.



Among the famous imported Mars drafting products are: **Left** – 1001 Mars-Technico push-button lead holder. **Above** – 1904 Mars-Lumograph drawing leads, 18 degrees, EXB to 9H. **Below** – 2886 Mars-Lumograph drawing pencils, 19 degrees, EXEXB to 9H; 2830 Mars-Lumograph Duralar—for drafting on Mylar®-base tracing film – 5 special degrees, K1 to K5; Mars-Lumochrom colored drawing pencils, 24 shades. **Not shown** – Mars Pocket-Technico for field use; Mars pencil and lead sharpeners; Mars Non-Print pencils and leads.

Mars Products are available at better engineering and drafting material suppliers.

®T.M. FOR duPONT'S POLYESTER FILM



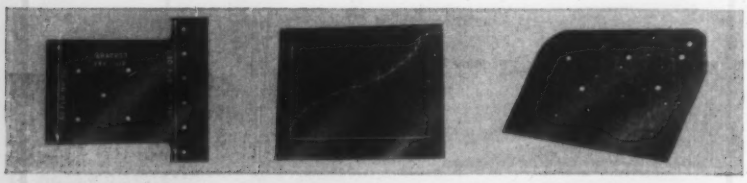
the pencil that's as good as it looks **MARS**

Sold at all good engineering and drawing material suppliers • J. S. STAEDTLER, INC. • Hackensack, N. J.

layout and template making time cut in half...

THE NEW STRIPPIT FLEX-O-DRILL

- **DRILLS, REAMS, SCRIBES, CENTER PUNCHES** to ± 0.002" WITHOUT base line drawing or height gauge layout!
- **EASY, ACCURATE POSITIONING**—quickly set to any reference point and to nearest 0.100" by adjustable steel tapes reading in both directions from zero. Micrometric gauges then bring settings to nearest 0.001". No optical scanning device needed.
- **LASTING ACCURACY!** Table is an actual ground surface plate. Bridge assembly is of heavy, accurately machined castings. Lead screws are precision ground and engaged only during micrometric gauge settings to minimize wear. All parts are corrosion-resistant. Bearings are protected against dust and chips by felt shields. Drill motor is heavy-duty industrial type.
- **¼" CAPACITY** in mild steel — stock up to 24" width, any length.
- **ALSO A PROVEN MONEY-SAVER** on pilot runs, low unit production.



Template drilled by Flex-O-Drill | *Layout scribed by Flex-O-Drill* | *Flex-O-Drill work piece*

WRITE FOR LITERATURE TODAY, and an actual demonstration at your plant:

WALES STRIPPIT INC.
216 Buell Road, Akron, New York
In Canada: Strippit Tool & Machine Company, Brampton, Ontario

A UNIT OF HOUDAILLE INDUSTRIES, INC.

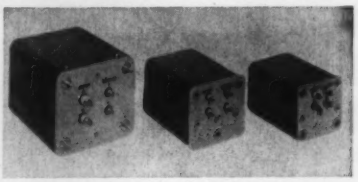
Circle 569 on Page 19

evaporative coolers. Units can be oiled easily through flexible oilers. Motors are available either for through-bolt mounting or for mounting in cradle bases. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 749 on Page 19

Transistorized Converters

dc to dc units have low noise levels



QC converters are designed for incorporation into a variety of battery-powered airborne and mobile electronic equipment, such as radio receivers, mobile telephone equipment, public address amplifiers, telemetering equipment, and radiation-measuring equipment. Converters provide an efficient means of obtaining higher voltages from standard 6, 12, or 28-v dc sources. Standard output voltages range from 50 to 1000 v dc, with 30 on 12-v models. Powers are to 200 w in 12-v models, to 150 w in 28-v models, and to 90 w in 6-v models. Units feature instantaneous starting and low noise levels. **Sorensen & Co. Inc.**, Richards Avenue, South Norwalk, Conn. B

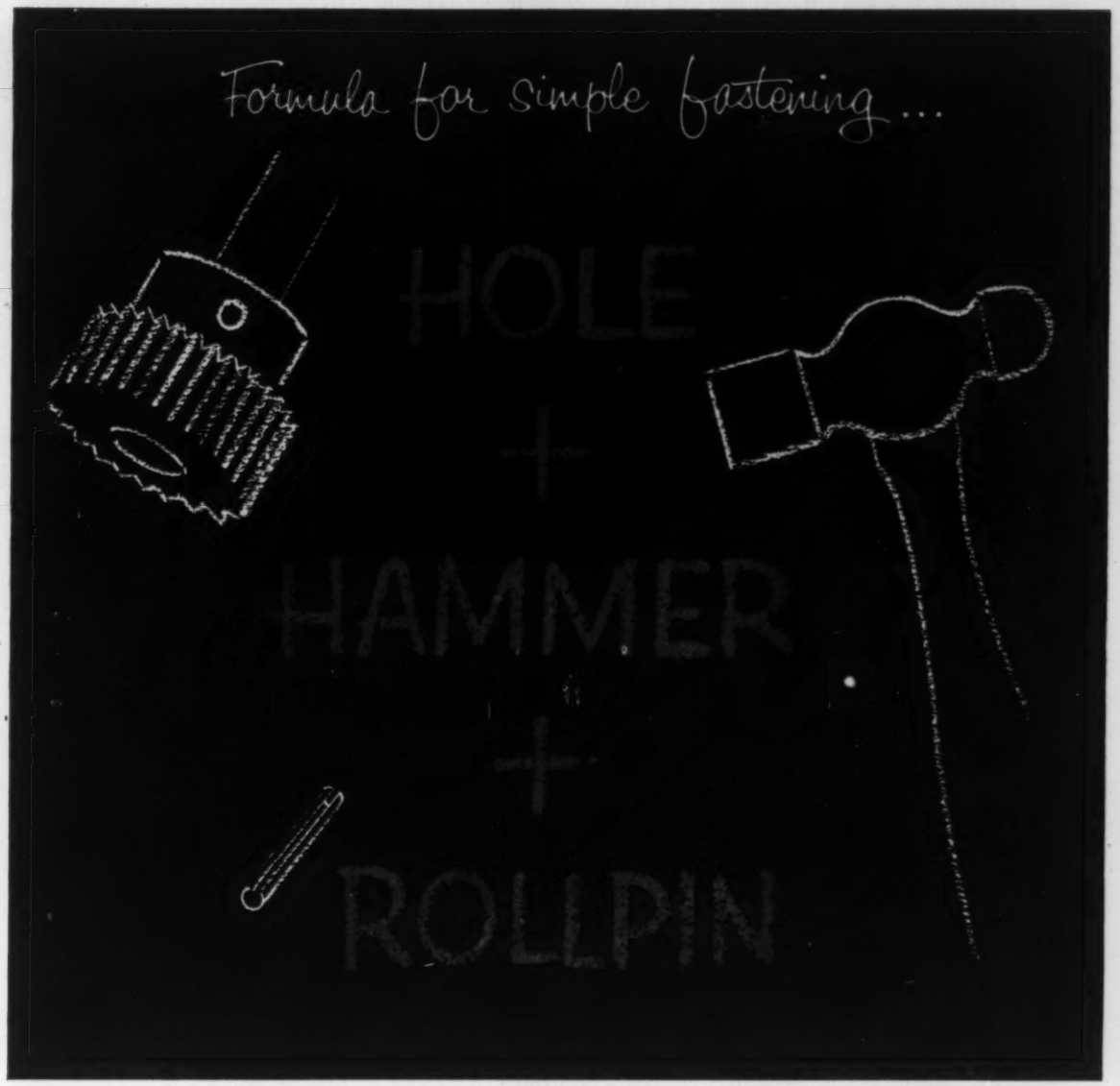
Circle 750 on Page 19

Heavy-Duty Power Relay

is 2 1/16 in. long and 1½ in. wide

High-power relay has ability to carry an extremely heavy load. A compact unit, it is 2 1/16 in. long and 1½ in. wide. Switch has a rating of 20 amp, 2 hp at 230 v ac. Either switch or coil can be replaced without removing relay from mounting. Unit is available for either side or bottom mounting. Variety of multiple-circuit arrangements is available. Coil voltages for ac include 24, 32, 115, and 230; for dc applications, voltages available are 12, 30, and 115. **Acro Div., Robertshaw-Fulton Controls Co.**, 2040 E. Main St., Columbus 16, Ohio. G

Circle 751 on Page 19



If you use locating dowels, hinge pins, rivets, set screws . . . or straight, knurled, tapered or cotter-type pins—you should look into the savings in time and money offered by the Rollpin formula. **(1)** You start with a straight production-drilled hole—no threading, peening or precision drilling is needed. (For example: permissible and typical hole tolerances for effective Rollpin installation are .125-.129 for the ⅛" diameter pin; .250-.256 for the ¼" pin.) **(2)** You need no more than a hammer . . . simply modified hand tooling, arbor press or hydraulic press to set the Rollpin into a secure, vibration-proof fit. **(3)** You just drive the Rollpin into the hole . . . and that's it. Spring action locks the Rollpin in place . . . regardless of impact loading, stress reversals or severe vibration. Yet it is easily drifted out . . . and can be reused in the same hole. For information on how Rollpin can simplify your fastening jobs, fill in and mail coupon below.

ROLLPIN®

ESNA

ELASTIC STOP NUT CORPORATION OF AMERICA

Elastic Stop Nut Corporation of America
Dept. R56-24, 2330 Vauxhall Road, Union, New Jersey

Please send the following free product information:

- ☐ Rollpin dimensional data
- ☐ Rollpin installation suggestions
- ☐ Here is drawing of our product. What self-locking fastener would you suggest?

Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

Circle 570 on Page 19

STOW FLEXIBLE SHAFTING
The Ideal PTO Drive

1¼" flexible shaft under tractor-trailer transmitting 10 HP.

1¼" core assembly pulled out of casing. Note steel-backed bronze sleeve bearing.

Here are five big reasons why flexible shafting is an ideal power take-off drive on trucks and tractor trailers.

FLEXIBLE SHAFTING:

1. Can connect a drive shaft and a driven shaft which are working at different angles and located in different planes.
2. Eliminates the need for accurate alignment.
3. Eliminates dangerously exposed revolving parts; no safety guards required.
4. Replaces connections affected by vibration.
5. Is economical because it is so easy to install and maintain.

Available with built-in bearings and couplings in sizes from ¼ inch to 1¼ inches in diameter—STOW flexible shafting can help solve your trucking and maintenance problems *in advance*. The know-how of 82 years' experience goes into every STOW flexible shaft!

STOW flexible shafts are being used on trucks and tractor-trailers to:

- Operate pumps for petroleum, other liquids and hydraulic pumps on dump trailers.
- Operate conveyors for grain and coal.
- Operate compressors on refrigeration trucks.

Our Engineering Department will be glad to work with you on any special drive problems. For complete data on flexible shafting sizes, torque capacities, and other specifications, write for STOW Engineering Bulletin, No. 570, and Tractor-Trailer Bulletin, No. 542.

STOW

STOW MANUFACTURING CO.

11 Shear St. Binghamton, New York

Circle 571 on Page 19

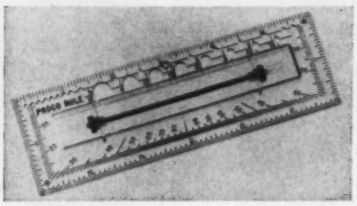
ENGINEERING DEPARTMENT

EQUIPMENT

Rolling Ruler

for use on any flat surface

For use on small drawings, Proco Rule incorporates a roller construction which carries it in a straight line across a flat surface, keeping edge parallel. Scale on each end permits easy, accurate spacing of



parallel lines. There is no side play. Rule contains a protractor which, combined with rolling action, makes possible the drawing of angles quickly. Rule also contains a template for small circles, and provides a method for making larger circles with radii to 6 in. Scales along two edges are in inches divided to sixteenths, and along the other two edges in inches divided to tenths. Over-all size of rule is 6 x 2 x ½ in. **Fullerton Engineering Sales Co.**, 4623 York Blvd., Los Angeles 41, Calif. L

Circle 752 on Page 19

Portable Planimeter

integrates flow from strip-chart records

Continuous, accurate integration of existing regular-size and 3 or 4-in. wide charts used with pneumatic control systems is accomplished with a portable planimeter. Conversion of unit from linear use to square root or square root to linear is accomplished by changing a cam. Linear accuracy is 0.5 per cent; accuracy on square root charts is 0.5 per cent at upper half and 1 per cent at lower end of scale. Output is read on a five-digit counter which

Why it sometimes pays to work in a vacuum

Metallurgical Products Department reports on super-strong vacuum-melted alloys . . . and on how they open vast new areas for mechanical design

By melting existing metals in a near-perfect vacuum, General Electric can give them remarkably improved mechanical properties. These better alloys, *plus* entirely new families of alloys which could not even be made by air melting processes, are lifting mechanical design limitations.

G-E vacuum-melted alloys are exceptionally strong and have increased ductility, making it possible to form, forge, or weld otherwise unworkable metals. Their consistent high purity gives operational dependability to critical gear trains and other machine components. And superior fatigue properties greatly extend the service life of springs and diaphragms.

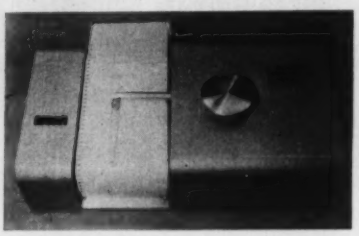
General Electric vacuum-melted alloys meet exacting specifications and can be ordered in sheets, bars, billets, wire, and castings. If you would like more technical information—or the assistance of a G-E engineer—call or write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Ave., Detroit 32, Michigan.*

METALLURGICAL PRODUCTS DEPARTMENT

GENERAL ELECTRIC

CARBOLOY® CEMENTED CARBIDES • MAN-MADE DIAMONDS • MAGNETIC MATERIALS • THERMISTORS • THYRITE® • VACUUM-MELTED ALLOYS

Circle 572 on Page 19

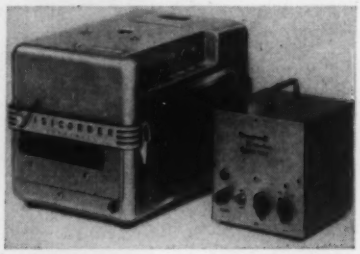


can be reset to zero. Unit operates on 110-v ac power. **Royson Engineering Co.**, Hatboro, Pa. E

Circle 753 on Page 19

Oscillographs

provide high recording frequencies

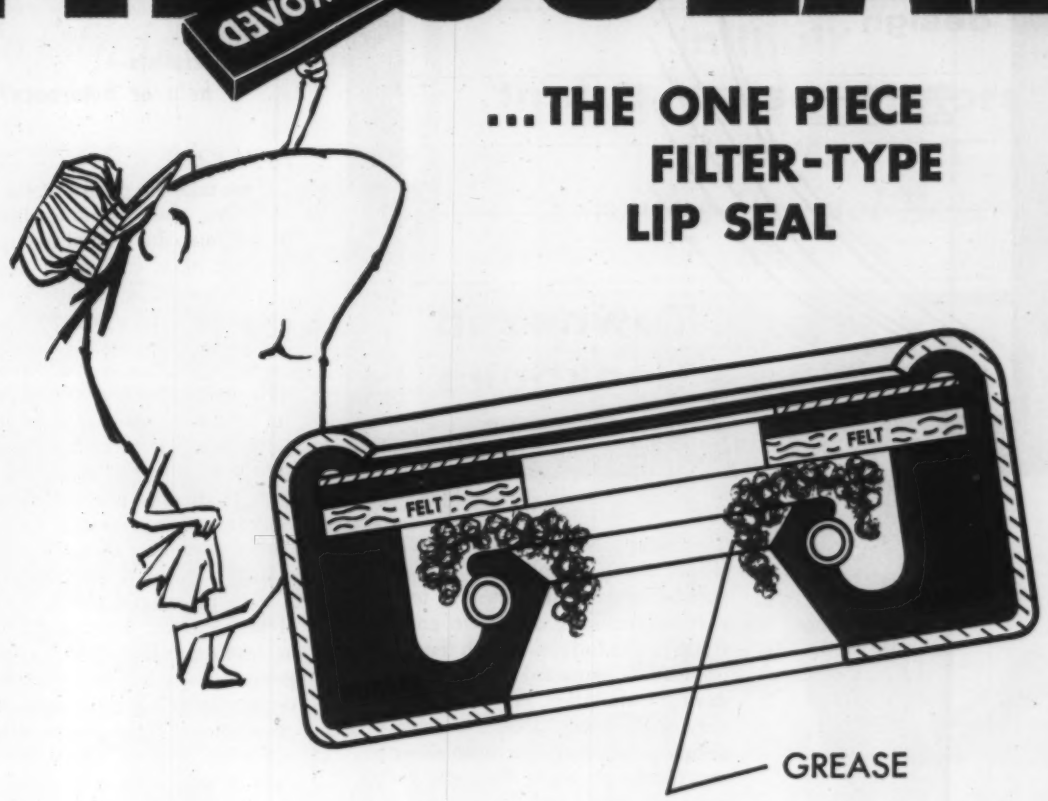


Series 906 Visicorder direct-reading oscillograph line includes two new models that provide higher recording frequencies and increased channel capacities. Two accessories, a timing unit (shown) and a record latensifier, facilitate operation of the units. Visicorders monitor and record a variety of electrical and mechanical phenomena during high-speed scientific and industrial testing operations. No. 906A-1 features high-sensitivity, miniature plug-in galvanometers and magnet assembly. Use of subminiature galvanometers permits 14 channels of data to be recorded directly at frequencies from dc to 5000 cps. No. 906A-2, with solid-frame galvanometers and magnet bank, provides for eight-channel recording at frequencies from dc to 2000 cps. Timing unit is a separately housed multivibrator oscillator that provides short, accurately spaced pulses to timing galvanometers of 0.01, 0.1, or 1 sec. Legible records within a few seconds are possible with bench-mounted unit that latensifies and spools Visicorder records. **Industrial Products Group, Minneapolis-Honeywell Regulator Co.**, 5200 E. Evans Ave., Denver 22, Colo. K

Circle 754 on Page 19

FILTOSEAL

...THE ONE PIECE FILTER-TYPE LIP SEAL



This *new* IPC lip type oil seal neatly combines the correct synthetic compound, for *your* application, with a built-in felt and rubber filter – complete with case in one compact assembly.

• • •

The bonding of felt to rubber ensures far better seal performance when abrasive particles or other foreign matter are likely to be encountered. IPC's "FILTOSEAL" protects the seal lip from being buffeted, worn or damaged.

By using a *custom* approach to case design IPC engineers can frequently eliminate the need for separate parts which add to assembly costs or maintenance problems. *More,* "FILTOSEAL" can provide adequate seal lip lubrication by incorporating a cavity for preloading lubricant.

Here is a *combination workhorse.* "FILTOSEAL" will answer more problems involving abrasive conditions than anything you've seen so far *and, do it all in one compact unit!* Let's hear about your lip type seal applications. We'll be happy to make a recommendation.

IPC

OIL SEALS / PACKINGS / PRECISION MOLDING
Custom designed . . . for your application.

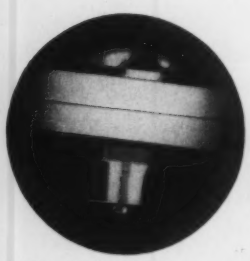
INTERNATIONAL PACKINGS CORPORATION
Bristol, New Hampshire

P1

Townsend lockbolts* give the designer great flexibility, for they may be used in either shear or tension applications, and have great resistance to fatigue. A high tensile pre-load is imparted to the joint during installation, which gives a very high shear value. No overdesign is necessary, because shear and tensile pre-load values are the same in every joint.

The setting gun swages the collar to the locking grooves on the pin, and breaks off the projecting pin tail as a pre-determined break-load is reached. The gun's cycling action cannot be altered, and even men with no special skill can produce strong, uniform, economical joints.

For more information on Townsend lockbolts, request a complete demonstration right at your desk, or write for Bulletin TL-101. Townsend Company, P. O. Box 237-E, New Brighton, Pa.



*Licensed under Huck patents RE 22,792; 2,114,493; 2,527,307; 2,531,048; 2,531,049 and 2,754,703

The Fastening Authority

Townsend

COMPANY • ESTABLISHED 1816

NEW BRIGHTON, PENNSYLVANIA

Sales Offices in Principal Cities

Cherry Rivet Division • Santa Ana, California

Professional Viewpoints

Specialists— help or hindrance?

To the Editor:

If we take the plaints of the value engineers, the maintainability engineers, and the reliability engineers to heart, then equipment designers as a class must be a pretty incompetent group! During the last ten years there seems to have sprung up a fad of organizing specialized groups with the avowed purpose of exploiting presumed weaknesses in the experience armor of the average design group. If the conclusions of these groups are regarded as fact, the equipment we design is neither as cheap, nor as reliable, nor as maintainable as would be desirable.

To support these claims are reams of publications, scheduled seminars at leading colleges, and organized groups mostly within industrial concerns supplying equipment to the government. These groups command attention because they appear to start at top level of government purchasing or advisory agencies, and "sell in" at top level in industry. They can be ignored no more easily than the "management efficiency" teams of the depression years who swept from the top down on promises of vast profit improvement.

And by pure statistics these teams enjoyed the fifty-fifty chance of success that any change might produce if they but avoided the temptation of loading the new staff with favored sons and nephews!

Problems Do Exist

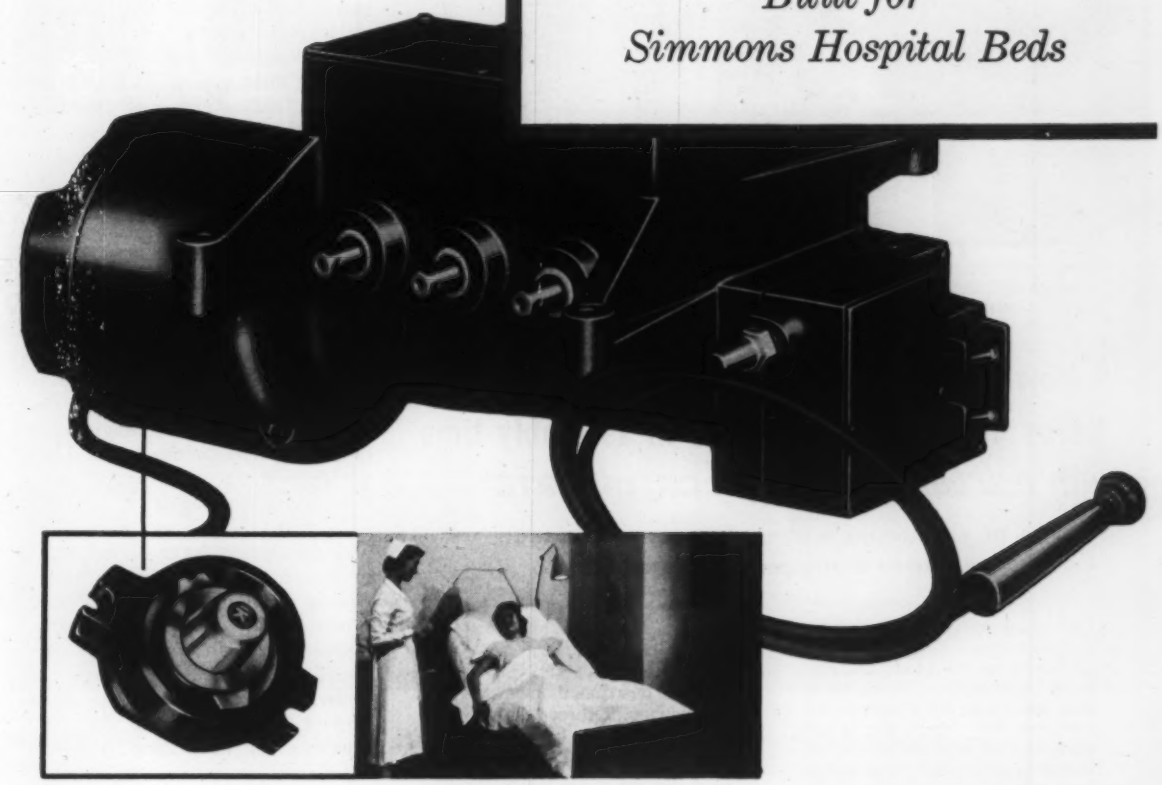
By the above I do not mean to imply that all is evil that stems from these specialized groups ostensibly researching in value, reliability, or maintainability engineering. The very existence of these groups and the literature they publish on the pertinent subjects point up and maintain a healthy consciousness of the problems. But one of my reasons for writing is to show that

Circle 575 on Page 19

Because Safety is a Must...

FRANKLIN USES KLIXON Protectors in their Inst-O-Verse* Motors

Built for Simmons Hospital Beds



The Simmons Company's "Sim-Matic" Bed provides maximum patient comfort by permitting personal, fingertip control of bed positions. The Franklin Electric 3 output shaft gear motor, shown above, is built for such hospital bed operation. It is equipped with "Inst-O-Verse" mechanism which allows minute adjustment of the bed by providing instant reversal of the motor.

Because safety is a must, Franklin Electric Co., Inc., uses KLIXON Protectors in their hospital bed motors as well as in other motors.

Here's the way they put it . . .

"Dependability is a major requirement of equipment used in hospitals, and dependable motor protection requires the positive action afforded by a KLIXON *Protector that cuts off power when conditions arise that would otherwise result in damage and loss of motor service. Patient safety also requires the positive protection provided by the* KLIXON *Protector."*

You, too, can keep motor-driven equipment operating dependably by specifying and using KLIXON-protected motors. They reduce maintenance costs, service calls, repairs and replacements. The additional cost is low . . . with exceptionally worthwhile benefits for both you and your customers.

*®Franklin Electric Co., Inc.

METALS & CONTROLS CORPORATION

Spencer Division

3202 Forest Street, Attleboro, Mass.

KLIXON®

Heli-Coil® stainless steel Screw-LOCK Insert is easily wound into tapped hole in aluminum housing. Spring tension of the locking coil retains screw securely, meets military specifications for locking torque and vibration.

How Carrier Corporation

Saves 40% in weight • 30% in assembly time ...with *HELI-COIL*® SCREW-LOCK INSERTS*

Use of aluminum makes Carrier installation lighter in Douglas DC-8 Jetliner

To reduce weight in the refrigeration system designed for air conditioning the giant Douglas DC-8 Jetliner, Carrier engineers used aluminum alloy compressor castings. To obtain maximum performance and reliability of threaded connections exposed to heat and vibration encountered at 600 mph, they selected the *Heli-Coil* stainless steel wire thread, *internal locking* Screw-LOCK Insert.

The results: design simplified, boss areas minimized, weight reduced as much as 40%, lock nuts and lock wiring eliminated. Now one man assembles the entire unit in 30% less time than before ... and danger of thread failure and screw loosening has ended!

Manufacturers in every field are relying on one-piece, stainless steel *Heli-Coil* Screw-LOCK Inserts to meet torque and vibration specs... protect threads against wear, stripping, galling and corrosion... save costs, space and weight. *Patented

HELI-COIL CORPORATION
DANBURY, CONNECTICUT

HELI-COIL CORPORATION, 502 Shelter Rock Lane, Danbury, Connecticut
I'd like more information on *Heli-Coil* Screw-LOCK Inserts

NAME_____ TITLE_____
FIRM_____
ADDRESS_____
CITY_____ ZONE____ STATE_____ 1508

IN CANADA: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

value, reliability, and maintainability are not new problems; nor are they old problems that have lain dormant and ignored because of any alleged esoteric nature! They have always been, and always will be, integral parts of design; but they are only a few of the many parts of the over-all design job.

The Ingredients of Design

In a way, design philosophy is based on the premise that there are six ways to skin a cat. And to be sure one comes up with the best design, he must exploit, at least briefly, the "six" avenues of approach. Design philosophy has to be tempered to the job, also. A single-purpose machine, or an experimental model, can't afford the design research that is easily paid for in manufacturing savings as in the case of the long-term production type job. Other considerations are: What delivery schedule has been promised for the design effort? Has time been allowed for cost, value, or other refinement analysis? Was the bid so competitive that design effort must be pared to the bone? These questions must be answered before the design effort begins.

Within this philosophy, then, actual parameters have to be set up to govern the details of the design. Among these parameters are end-product quality, life expectancy required, provision for maintenance, specifications stipulated by the customer, size restrictions (the omnipresent bugaboo of the designer), alteration or adaptation flexibility, detail cost analyses, and so on — with one eye on the delivery date, of course.

Give and Take

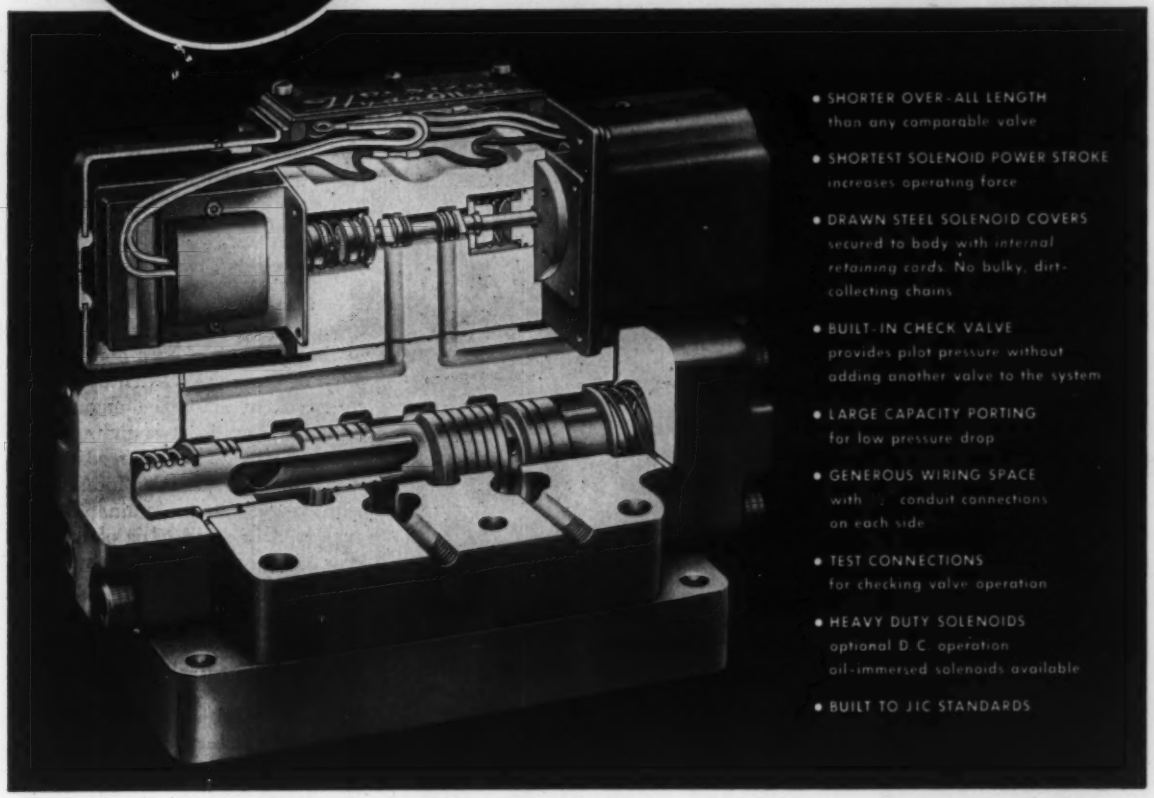
Perhaps the simplest yet most accurately descriptive definition of design would be the one word "compromise." In the first place a compromise connotes due consideration of many factors. And this is design. And compromise connotes a deliberate choice or judgment. This is the choice in design emphasis which the designer must make.

And compromise also connotes sacrifice. In aircraft design, many desirable design factors and features are sacrificed to weight reduction. Reliability has often been sacrificed

NEW from DENISON

4-WAY VALVES

Pilot-operated, solenoid-controlled for hydraulic systems up to 5000 psi



- SHORTER OVER-ALL LENGTH than any comparable valve
- SHORTEST SOLENOID POWER STROKE increases operating force
- DRAWN STEEL SOLENOID COVERS secured to body with internal retaining cords. No bulky, dirt-collecting chains
- BUILT-IN CHECK VALVE provides pilot pressure without adding another valve to the system
- LARGE CAPACITY PORTING for low pressure drop
- GENEROUS WIRING SPACE with ½" conduit connections on each side
- TEST CONNECTIONS for checking valve operation
- HEAVY DUTY SOLENOIDS optional D.C. operation oil-immersed solenoids available
- BUILT TO JIC STANDARDS

SHOCKLESS HYDRAULIC CONTROL for any directional control requirement is assured with Denison's new line of 4-Way Valves.

Here are *more reasons why* the exceptional design versatility of these new 4-Way Valves is important to Hydraulic Engineers—

1. Provide fast, rapid-cycle directional control of hydraulic flows up to 30 gpm.
2. Operating pressures range up to 5000 psi for both ¼" and ¾" valve sizes.
3. Operate in any porting and positioning combination.
4. Solenoid-operated ¼" valve capacity—5 gpm.
5. Pilot-operated, solenoid-controlled ¾" valve capacity—30 gpm.
6. Choice of spool types and spool positioning provides unlimited combinations for a wide range of applications.
7. Adjustable pilot chokes available for smooth spool reversal.
8. Interchangeable parts simplify service and model changes in the field.
9. Easily modified for operation on internal or external pilot pressure by rotating solenoid valve 180°.

DESIGNERS ENGINEERS!

Send for Bulletins VD-7, VD-8 and 240-B

for full details write

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

Denison Stocking Branch Offices: LOS ANGELES • CHICAGO
DETROIT • ATLANTA • HOUSTON • NEWARK • CLEVELAND

Denison and Denison HydrOILics are registered trademarks of Denison Eng. Div., ABSCO

DENISON HydrOILics

HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

Circle 578 on Page 19

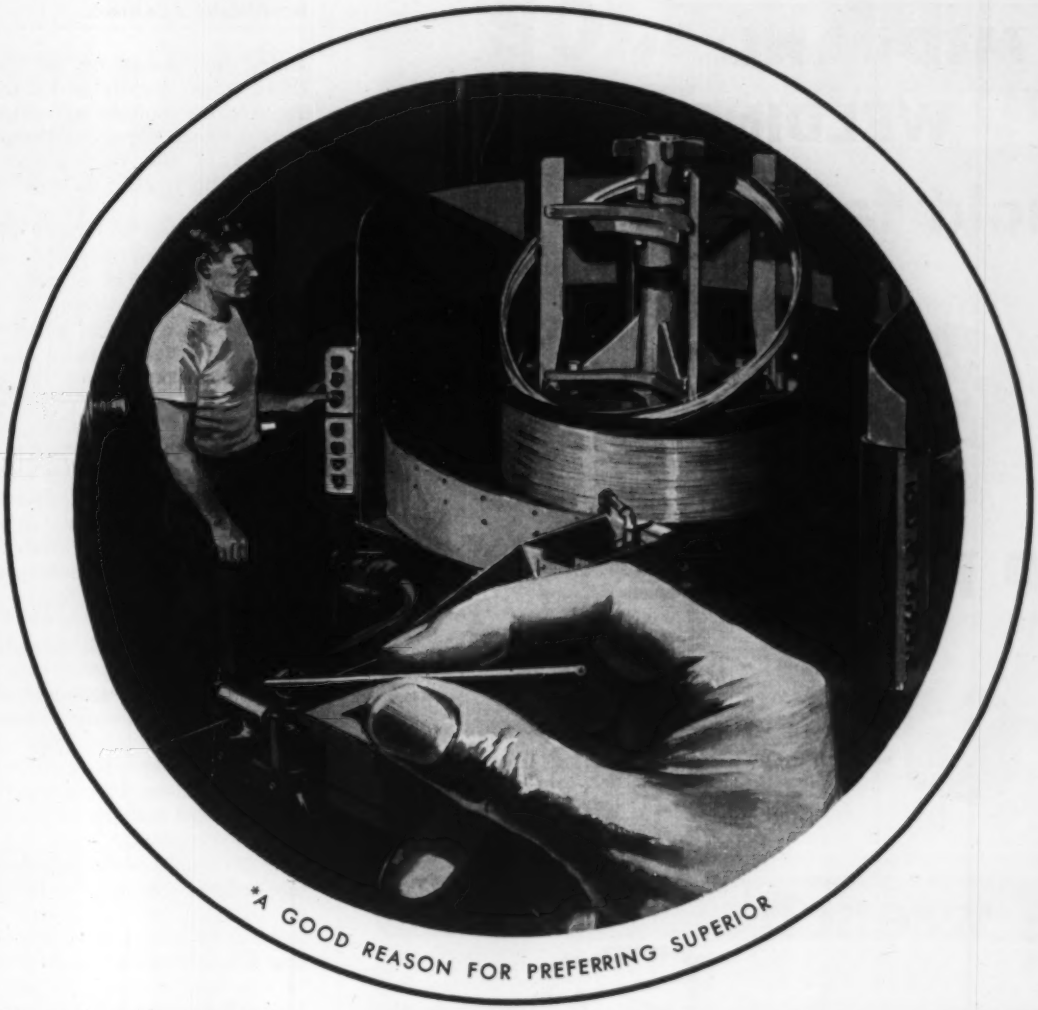
WHAT'S YOUR CLAMPING PROBLEM?
WITTEK
HAS THE ANSWER
Here is a selection from among the many different types and sizes of hose clamps designed and manufactured by WITTEK. Whatever the hose connecting problem, it's a safe bet that WITTEK (leader for over a quarter century) has the exact type and size clamp to do the job right! Let WITTEK help solve your clamping problems. Write today.
9187
WITTEK MANUFACTURING COMPANY
4349 West 24th Place • Chicago 23, Illinois

to miniaturization. In much military equipment maintainability is sacrificed to replaceability and expendable subunits. The automobile has sacrificed maintainability of its engine compartment to milady's desire for a low small hood and her husband's craving for more horsepower under the same small hood. This is design! The philosophy is determined by the end-purpose of the equipment under consideration, and the actual design parameters are pretty much established by the market or customer. And the designer, or his immediate supervisor, sits continuously in the "hot" judgment seat compromising one facet of his design against another.

The Pressure Groups

But the designer is also human, I believe. Yes, even temperamental, at times. He picks up a documented piece of literature written by the director of maintenance engineering in some impressive-sounding government agency and he reads of the deplorable lack of design forethought with respect to maintainability as evidenced in some piece of military gear. Or he reads of many such examples. And he reads suggestions for educating and training designers in this all-important but overlooked field. But please note that he does not discover in the document any reference to military specs stipulating size restrictions, or any other of the many limitations under which the designer labors. By inference, he is as free as a bird, and design oversights are the feathers of his profession.

Or the designer picks up a treatise on reliability. Shortly his head begins to hang in shame as he reads of the crimes he has committed in this field. And he resolves to replace all electronic tubes on the military approved list with long-life $15 to $25 tubes! However, at this point a flyer comes through from the value engineering department decrying the use of 57-cent handles on a chassis that could be removed by tugging on two ½-in. diam captive screws. Of course, there may be a multi-pin connector at the rear of the chassis requiring a 35-lb pull to disengage; besides, the specs may have stipulated the use of protective brackets to prevent



New—capillary tubing in 3000 ft. lengths for industrial instrumentation

***Improved bore uniformity, broader size range, flow tested to your specifications**

To meet the demands of modern instrument design and automated fabrication, Superior is now offering seamless capillary tubing in lengths up to 3000 ft. It is available in nine different materials from select-quality raw stock, including stainless steel, carbon steel, nickel and nickel alloy.

Scrupulous care in manufacture results in a finished product that is bright and scalefree, with an extremely smooth, uniform bore. The tubing is easy to weld, braze or solder. ODs range up to 5/16 in.—IDs from .004 to .040 in. maximum.

When you order capillary tubing by Superior you are assured that your specifications will be met. In addition to 100% dimensional, pressure and finish inspections, we also can test lengths for flow rates with the latest equipment when specified. Rates can be varied from 5 to 3700 cc per min.

More information on Superior's improved capillary tubing products is yours for the asking. Send coupon today.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010 in. to ½ in. OD—certain analyses in light walls up to 2½ in. OD

West Coast: Pacific Tube Company, 5710 Smithway St., Los Angeles 22, Calif. RAymond 3-1331

SUPERIOR TUBE COMPANY
2010 Germantown Ave., Norristown, Pa.

Send me a copy of new Data Memorandum 11, on capillary tubing.

Name_____ Title_____

Company_____

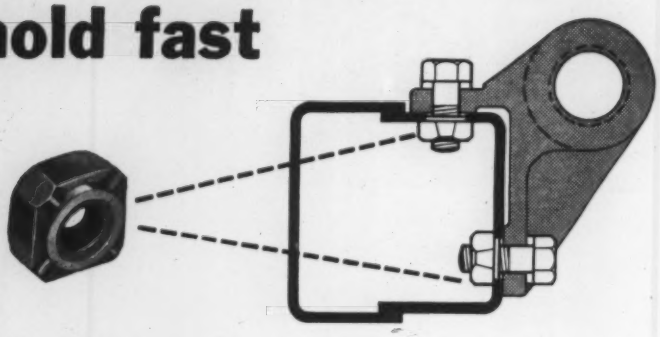
Street_____

City_____ Zone____ State_____

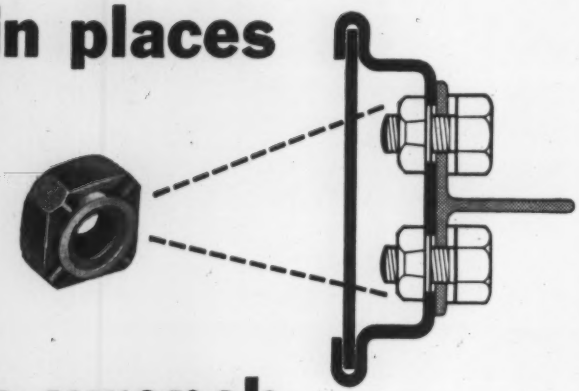
MIDLAND

WELDING NUTS

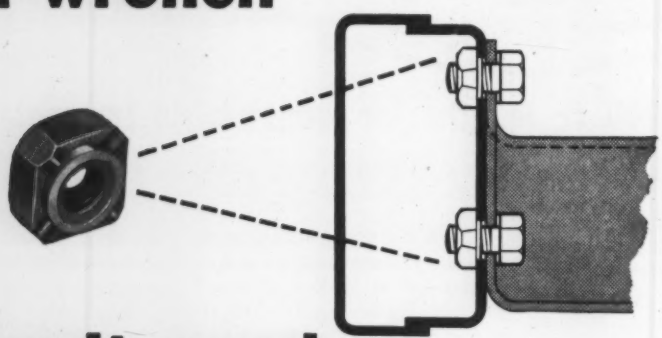
hold fast



in places



a wrench



can't reach

Looking for cost and time-saving tips? Send for the free booklet showing you how to "Save With Midland Welding Nuts."

MR **MIDLAND-ROSS CORPORATION**

OWOSSO DIVISION • OWOSSO, MICHIGAN

MIDLAND WELD NUT

setting the chassis on its control knobs when withdrawn for servicing. And the confused but conscientious designer silently contemplates the ire of his value-engineering group if he replaces $2 tubes with $15 ones!

In desperation he rereads the reliability treatise to discover even just a hint of the value of this reliability. Isn't this worth something? A ratio, perhaps—twice the life, worth twice the price? But no; twice the life should be worth twice the price plus maintenance cost of replacing the tube. But he finds no helpful figures. He is amazed to find no reference to any costs. Here are specialists in one narrow field only of design, and apparently they are unequipped to equate their own factor with value. The design engineer, however, must equate and judge many factors.

So he searches back through the maintainability document. Again he finds practically no reference to the other factors of design. Reliability, maintainability, value: They are all treated as independent, all-important, sole end-results of design. And the misguided designer must be educated to appreciate each! At this point a thought begins to emerge in the designer's brain. A revolutionary thought! And the thought takes shape as an uncharitable conclusion that the educational program would be directed toward more virgin territory if it were given to the specialized groups rather than to the designer!

In line with the sentiments expressed above, other specialized groups, also, merit a word here. Human engineering is not without some merit. However, to give it undue emphasis without balancing the design effort against cost and other design factors would be poor management and could be fatal in a competitive economy. Furthermore, it is fatuous to assume that human engineering was utterly ignored during those years when it was not dignified by a specialized name.

The weight committee is another specialized group to make sporadic appearances within design departments. Again, their efforts are not without merit. The problem appears to be one of timing. Where within the design development pro-

Circle 581 on Page 19

gram should their contributions be solicited? Ideally, their experience should be omnipresent. To do a partial design before calling them in might easily involve expensive changes or redesign. But in the early stages, weight is but one of many problems. No individual parameter can be frozen. In fact, design freeze is usually a coincidental, multi-facet crystallization because of the obvious dependence of all factors on each other.

Conclusions

Speaking frankly, conclusion number one would be to beware of pseudo specialists who talk glibly, in fact somewhat evasively in terms of concrete facts or illustrations, and who find it difficult to include in their publications the other aspects and compromises of design. Their avoidance of other design factors betrays their own lack of over-all experience in the profession.

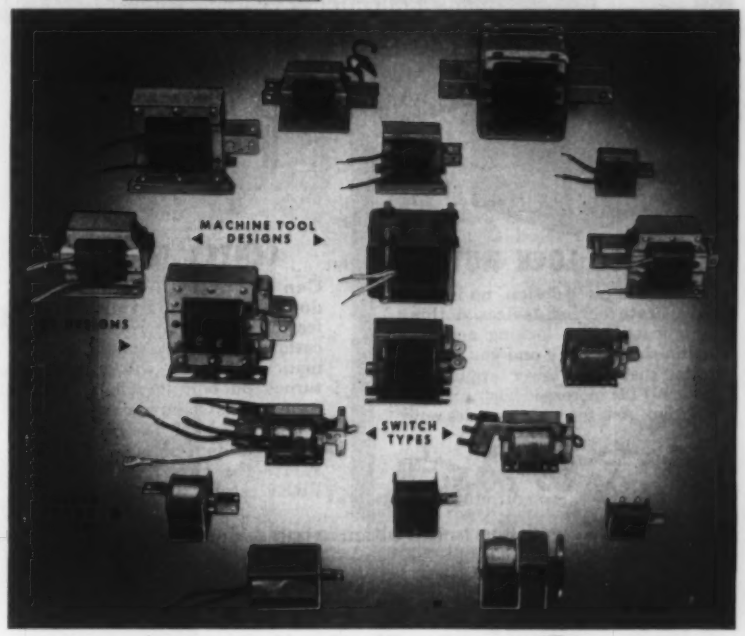
Second, however, we can conclude from the existence of these "specialists" that greater experience may be needed, at least at the supervisory levels, in our design groups. It is probable that our expanding technological economy has created design opportunities beyond the physical ability of the profession to fill them.

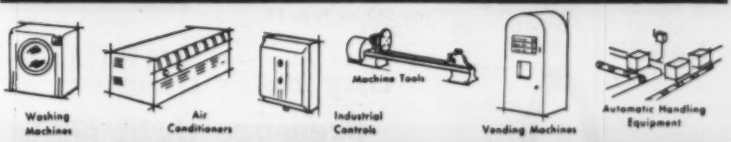
It would be interesting to obtain figures on the change in the average age of design supervisors. The responsibility of making wise compromise decisions, and for seeing that all aspects of a design are adequately considered, is left up to these men.

Conclusion number three would be that if enough men of sufficient experience were impossible to come by on the labor market, then a return to some form of the ancient, but disappearing, apprenticeship school is in order. But to give specialized education in value engineering, only, or maintainability engineering, only, or in any other single phase of design would be to neglect the real point in illustration—that our design force either needs experience improvement in all phases, or that opportunists are moving in by this simple medium of degrading our profession.

—A. I. Winslow
Foxboro, Mass.

SOLENOIDS
for *every* application





IMMEDIATE DELIVERY FROM STOCK . . .
OR CUSTOM ENGINEERED TO YOUR SPECIFICATIONS

A COMPLETE LINE OF CUSTOM-DESIGNED SOLENOIDS . . . Available from stock or designed and constructed to meet your specific requirements. Twenty-four hour delivery from date of order on stock items. Prompt estimate on specials upon receipt of b/p or specifications. Expert engineering assistance available.

LENGTHEN PRODUCT LIFE . . . The quality parts that go into a DORMEYER solenoid and their expert fabrication account for its rugged dependability. In turn, this long-lasting reliability increases product service life.

IMPROVE PRODUCT PERFORMANCE . . . Double shading coils in DORMEYER solenoids deliver high seating pull without hammer or excessive A-C hum and chatter. And phase-timing the plunger's stroke for maximum work eliminates any power drop-off.

REDUCE PRODUCTION PROBLEMS . . . Made to your specifications, DORMEYER solenoids feature close-tolerance component parts that eliminate many problems in product assembly. And their ruggedness withstands handling.

Dormeyer Solenoids are made for all commercial voltages and frequencies. Standard sizes from 1⅜" x 1⅜" to 3" x 3" . . . stroke lengths fractional to 2" . . . pull and/or push capacities to 35 lbs. Larger sizes made to specifications.

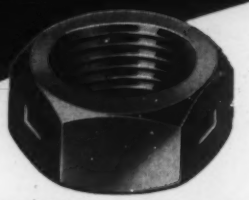
Also Manufacturers of Quality Transformers and Precision Coils.
TWO MODERN PLANTS IN CHICAGO AND KENTLAND, INDIANA

DORMEYER INDUSTRIES
3434 MILWAUKEE AVENUE • CHICAGO 41, ILLINOIS

Circle 582 on Page 19

2 GRIPCO LOCK NUTS

at low cost that can save you production time, speed application, and resist vibration



GRIPCO LOCK NUTS

Simple, one piece design, no inserts, no separate locking devices, nothing complicated. The locking action is within the nut itself and you get low initial cost with lower application costs, WITH increased customer satisfaction. Ask for your samples now.

CENTER LOCK NUT

Can be applied from either end, double chamfered, with locking feature in the center. Greater application speeds now possible. Automatically fed, they will lock wherever turned on bolt. Available in steel from stock. Other metals on special order. Send for samples. Complete data on sizes. Write for this new FREE catalog today.

ALL GRIPCO FASTENERS AVAILABLE FOR IMMEDIATE DELIVERY

GRIP NUT COMPANY

103 Maple Ave. • South Whitley, Ind.

Circle 583 on Page 19

tiny holes assure pressure tight seals

United's *exclusive patented* feature

United's exclusive, patented* self-energized metallic O-rings have tiny holes in the hollow ring wall. The holes are to balance the interior and exterior pressures in order that the ring may respond to variation in deflection of the sealing surfaces with a natural resilience uninhibited by the external pressure.

In metal-to-metal applications, self-energized metallic O-rings are capable of forming positive, permanent, non-corrosive, static seals under extreme temperatures from —321°F. to 1800°F., and under pressures equal to ultimate compression stress of the metal itself. Available in various metals and finishes, 3/8" dia. to any size or configuration. United also makes non-vented and pressure-filled O-rings; and wire and brazing O-rings.

Write for free 22-page booklet (on your letterhead please).

PATENTS 2,809,269; *2,837,360

UNITED METALLIC "O" RING CORP.

Dayton, Ohio • Box 1036

Division of United Aircraft Products, Inc.

Circle 584 on Page 19

THE ENGINEER'S Library

Recent Books

Company Climate and Creativity. *104 pages, 8½ by 11 in., clothbound; published by and available from Industrial Relations News, 230 West 41st St., New York 36, N. Y.; $10.00 per copy.*

Results of a survey on industrial climate versus personal creativity are summarized in this book. Statements and opinions collected from 105 scientists and administrators indicate the present status of this problem from the viewpoint of the individual and of industry, and why such a situation exists. Suggestions are also made for establishing better conditions and relationships for mutual benefit.

A three-part article, "The Ideal Creative Supervisor," which appeared in MACHINE DESIGN starting with the September 18, 1958, issue, was based upon one of the chapters in this book.

Fluid-Power Controls. *By John J. Pippenger and Richard M. Koff; 254 pages, 6 by 9 in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN; *$9.00 per copy postpaid.*

Intended as practical assistance to the hydraulic circuit designer, this guidebook of control valves describes their construction, operation, circuit applications and combinations, causes of failure, and maintenance. Also discussed are pumps, reservoirs, plumbing, fuses, switches, and types of circuits.

Statistics of Extremes. *By Emil J. Gumbel, adjunct professor of industrial engineering, Columbia University; 375 pages, 6 by 9 in., clothbound; published by Columbia University Press, 2960 Broadway, New York 27, N. Y.; available from* MACHINE DESIGN; *$15.00 per copy postpaid.*

This book deals with the far left and right sections of the normal distribution curve rather than the central portion used for most sta-

Silicone Sponge Rubber

remains flexible at extreme temperatures
—100° F to 500° F

COHRlastic R-10470 silicone sponge rubber has a dense, uniform, non-absorbing closed cell structure, highly suitable for soft gasketing, vibration dampening, fairing strips, seals, pads, bumpers, dynamic cushions and other applications where resiliency at extreme temperatures is required. It has superior compression set resistance, excellent dielectric properties, immunity to aging, ozone and weather hardening and good chemical resistance — non-sticking, odorless, non-corrosive.

COHRlastic R-10470 can be bonded to metals, plastics, fabrics or silicone rubber. Sheets 24″ x 24″ and in thicknesses 1/16″ through 1/2″ are available from stock. Larger sizes up to 30″ x 30″ and special molded and extruded shapes are made to order. CHR silicone sponge rubber is sold nationally through distributors.

FREE SAMPLES and folder — write, phone or use inquiry service.

COHRlastic R-10470
Silicone Sponge Rubber

SPECIFICATIONS:

COHRlastic R-10470 meets many specifications. Some are listed below:

AMS 3195
AMS 3196
MIL-R-6130A type 2
Boeing BMS 1-23
Martin MC1 4546
Martin MB 6130
Bendix ES 0709
Douglas DMS 1597
Lockheed LAC 1-924

PROPERTIES	Range of typical properties COHRlastic R-10470	Typical accepted standards
Tensile	50-130 psi	40 psi, min.
Elongation	175-225%	125% min.
Water absorption (Immersion 24 hrs. @ 75°F.)	3-6%	10% max.
Density, lbs./cu. in.	.020-.030 (firm)	.030 max.
	.013-.018 (medium)	.020 max.
Low temperature brittleness (5 hrs. @ −100°F., bend flat)	No cracking	No cracking
Compression deflection (compressed to 75% of original thickness)		
Room temperature		
Type firm	12-18 psi range[1]	12 min.-20 max. psi
Type medium	8-14 psi range[1]	6 min.-14 max. psi
−65°F. pct. difference	−10% to +15%[1]	
212°F. pct. difference	+5% to +10%[1]	
Compression set (compressed to 50% of original thickness)		
22 hrs. @ 70°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ −65°F	0-5% (firm)[1]	10% max.
	5-30% (medium)[1]	40% max.
22 hrs. @ 212°F	10-25% (firm)[1]	30% max.
	20-50% (medium)[1]	60% max.

1 ASTM D 1056-56T

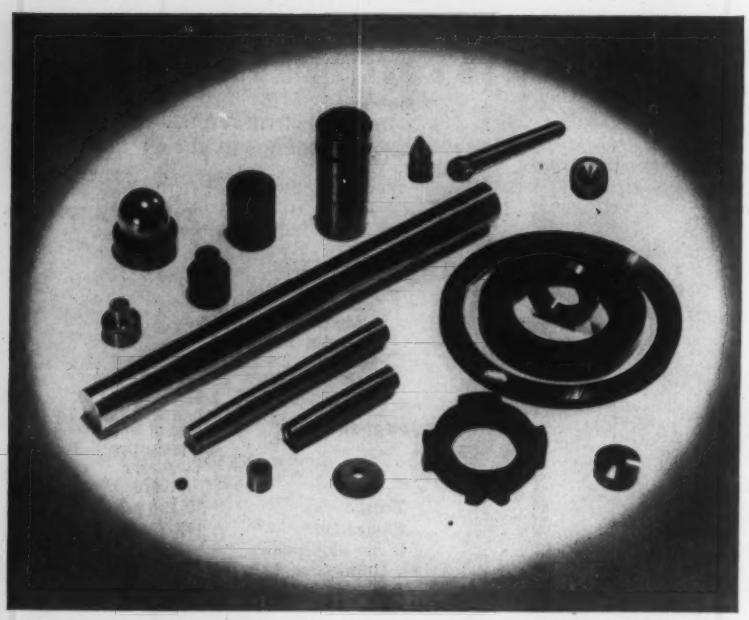
CHR products include:

COHRlastic Aircraft Products — *Airframe and engine seals, firewall seals, coated fabrics and ducts*
COHRlastic Silicone Rubber Products — *Silicone rubber moldings and extrusions, silicone rubber sheets, silicone sponge rubber*
Temp-R-Tapes — *Pressure sensitive, thermal curing Teflon and silicone tapes*
Allied Products — *COHRlastic silicone cements and conductive gasketing*

Leader In Fabrication of Silicone Rubber

CONNECTICUT HARD RUBBER COMPANY

Main Office: New Haven 9, Connecticut



Kennametal can be supplied as standard rectangular blanks, discs, rods, tubes, flats, balls, rings . . . and can be extruded, pressed, machined or ground . . . to precise tolerances for specific requirements.

When other materials won't do ...KENNAMETAL* usually will

High hardness and strength; resistance to abrasion, corrosion and high temperatures set Kennametal hard carbide alloys apart from all other design materials.

- Kennametal has an extremely high YME . . . up to 94 million psi compared to steel's 30 million.
- Some grades of Kennametal have a density as high as 15.5 gms/cc . . . twice that of heat treated steel . . . while other grades stand up for days in boiling 5% HNO_3 and 5% H_2SO_4.
- Kennametal is extremely hard . . . up to 94.7 Rockwell A.
- Kentanium,* a series of hard titanium carbide alloys, retains sufficient strength for many applications at temperatures as high as 2200°F.

Very broad applications have been found for these remarkable characteristics: long-wearing plungers, compressor cylinder liners, seal rings for rotary pumps, bushings, valve parts, high temperature sensor elements and hundreds of other critical component parts are being made from Kennametal.

Pushing design frontiers ahead means forcing back the barriers of wear, pressures and temperatures. As man's imagination continues to develop ideas, new problems are encountered . . . for which Kennametal often has the answer. For example, here's how a pump manufacturer recently used Kennametal: problem—to obtain a large pumping capacity from a small pump . . . without increasing pump size. Solution—use Kennametal for critical operating parts to permit faster pump speeds and higher pressures. A simple answer, but made possible only by the great wear- and corrosion-resistant characteristics of Kennametal.

Perhaps Kennametal can solve one of your problems. If you'd like more information, just write Department MD, KENNAMETAL INC., Latrobe, Pennsylvania.

5780

*Trademark

INDUSTRY AND KENNAMETAL ...Partners in Progress

tistical calculations. The idea that everything is normal or can be made normal by a logarithmic transformation is neither practical nor true.

The usual averages — median, mode, mean—are not sufficient to characterize the distribution of extremes, and a new type of "average," the characteristic extreme, is introduced. Extreme values are linked to small probabilities, and the book explores the behavior of unlimited distributions at infinity where the size, rather than the number, of rare events is significant.

Physical Laws and Effects. *By C. F. Hix Jr. and R. P. Alley; 291 pages, 6 by 9 in., clothbound; published by John Wiley & Sons Inc., 440 Fourth Ave., New York 16, N. Y.; available from* MACHINE DESIGN; *$7.95 per copy postpaid.*

This collection of laws and effects serves as a practical part of the engineering search for explanations, inventions, and new ideas. Each alphabetized item is briefly described; illustrated; expressed in magnitude by equation, units, or words; referenced to outside literature; and concluded with a list of quantities or terms used in application. Indexing and cross referencing aid in quick location of the law or effect in question.

Manufacturers' Publications

A Simplified Technique of Control System Engineering. *By George K. Tucker and Doris M. Wills; 303 pages, 6 by 9 in., clothbound; published by and available from Brown Instruments Div., Mail Station 0-280, Minneapolis-Honeywell Regulator Co., Wayne & Windrim Avenues, Philadelphia 44, Pa.; $5.00 per copy.*

A practical method of analyzing process-control systems is presented in this book. Nontechnical language, formulas, and graphs explain how control systems are designed, how to predict their performance, and how to improve them. Various samples and a complete problem and evaluation of its solution illustrate the application of the dynamic-analysis method.

Molded Rubber Handbook. *45 pages, 5½ by 8½ in., paperbound; published by and available from Stowe-Woodward Inc.,*

Circle 586 on Page 19

Circle 587 on Page 19→

FAST! – *up to 200 cps*

SENSITIVE! – *low as ±2.5 milliwatts*

NEW CLARE Type HGS Mercury-Wetted Contact Relay

IDEALLY SUITED TO HIGH SPEED SWITCHING DEVICES

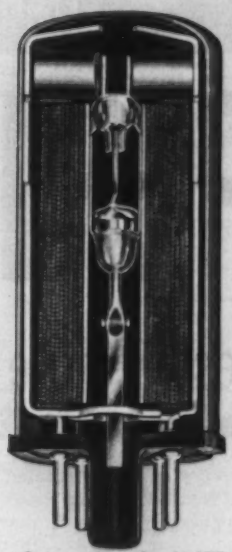
The Type HGS Relay is a new variety of CLARE Mercury-Wetted Contact Relay, developed to meet the needs of modern design engineers for faster and more sensitive relays. The HGS Relay is especially suited to all types of high-speed switching devices, over-voltage and overload protection devices and high-power chopper applications.

Operating speeds may be up to 200 cps or more. Sensitivity may be as low as ±2.5 milliwatts for a bi-stable adjustment, as low as 5 milliwatts for a single-side-stable adjustment. Contact rating is 2 amperes, 500 volts, with a limit of 100 volt-amperes.

Supplements Clare HG and HGP Relays

The new CLARE Type HGS Relay will not supplant the revolutionary Types HG and HGP. It will supplement these relays in applications which require higher speed or greater sensitivity.

The Clare Type HGS is similar to the Types HG and HGP except that the HGS is always biased with permanent magnets. These are adjusted to single-side-stable or bi-stable operation.



Cutaway view of a CLARE Type HGS Relay. Mercury-wetted contact switch is sealed in glass and surrounded by the operating coil. Biasing magnets are attached to the upper ends of the side plates.

ELECTRICAL FEATURES

Long Life: Over one billion operations at rated load.

Operation Speed: Up to 200 cps with consistent performance. Higher if some variation is tolerable.

High Sensitivity: 5 milliwatts for single-side-stable adjustment; ±2.5 milliwatts for bi-stable adjustments.

Stable Operation: 0.1 millisecond maximum operating time variation.

Freedom from Chatter: Absolutely NO CONTACT BOUNCE.

Low, Stable Contact Resistance: Initial contact resistance, 25 to 50 milliohms, does not vary by more than 1 or 2 milliohms during life of contacts.

Low Ratio Coil Inductance: Low inductance-to-resistance ratio of coil suits relay well for transistor-drive applications.

MECHANICAL FEATURES

Conveniences: Small, light-weight; plugs in like vacuum tube; completely protected from atmospheric conditions; contacts cannot wear, weld, stick or chatter; tamper-proof; requires no maintenance.

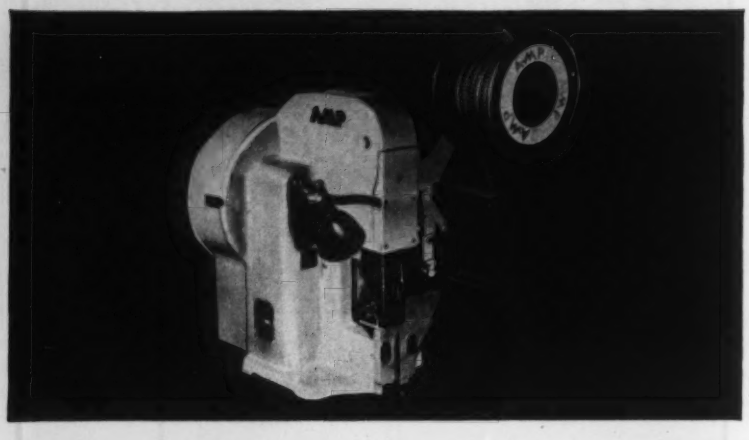
Durability: Easily withstands normal handling and transportation shocks.

Send for CLARE Sales Engineering Bulletin No. 125 for complete information on the new Type HGS Relay. Bulletins 120 and 122 describe HG and HGP Relays. Write: C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: C. P. Clare Canada Ltd., 2700 Jane Street, Toronto 15. Cable Address: CLARELAY.

CLARE RELAYS

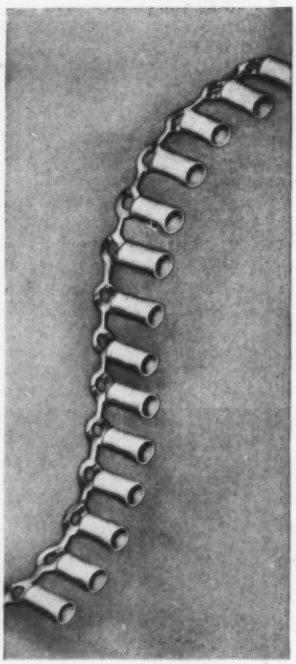
FIRST in the industrial field

With the AMP Termination Technique



EXPERIENCE

is the best feature



All the unusual features of the A-MP tool-and-terminal method which have created AMP's outstanding reputation are a result of one major feature: experience or "know how".

This experience is unmatched by any other organization in the world. The proof of it is in AMP's electrical circuit terminations, that is, a fine A-MP terminal crimped precisely and uniformly to your circuitry leads. A-MP "know-how" also means the lowest total installed cost—no extra parts, no multi-step assembly operations . . . just an A-MP tool and a supply of A-MP terminals.

Highest reliability without fuss or muss at the lowest total installed cost anywhere . . . experience says you can't beat such a combination.

Why not write for more information today on your particular circuitry termination requirements.

AMP INCORPORATED

General Offices: Harrisburg, Pennsylvania

A-MP products and engineering assistance are available through subsidiary companies in: Canada • England • France • Holland • Japan

Newton Upper Falls 64, Mass.; $2.00 per copy.

General discussion in this handbook includes all types of rubber. Properties, uses, and limitations of particular formulations are compared. Basic processing methods, design factors, and ASTM specification designations are described.

New Standards

American Standard, ASA Y14.9-1958, Section 9, Forgings, American Drafting Standards Manual. *16 pages, 8½ by 11 in., paperbound, stapled; published by and available from The American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.; $1.50 per copy.*

This standard describes forgings, materials used, and production methods. Forging design is discussed with relation to draft angles, fillet and corner radii, and section thicknesses. General tolerances are given for shrinkage, die wear, mismatch, and for later machining requirements. Drawing features peculiar to forgings are illustrated to reduce differences of interpretation and costly errors.

Government Publications

OTS Technical Reports. *Copies are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.*

The following reports are available:

PB 121645. Metallography of Titanium Alloys. By H. R. Ogden and F. C. Holden, Battelle Memorial Institute; 96 pages, 8¼ by 11 in., ringbound; $2.75 per copy. (General description of structures as affected by composition and thermal treatment; microstructure photographs of commercial alloys as affected by fabrication and thermal treatment; includes glossary of terms and description of sample preparation.)

PB 121647. The Engineering Properties of Commercial Titanium Alloys. By M. W. Mote, R. B. Hooper and P. D. Frost, Battelle Memorial Institute; 248 pages, 8¼ by 11 in., paperbound; $4.00 per copy. (Includes data on semicommercial and experimental alloys; four producers of mill products, listed as source information, can supply majority of alloys and forms described.)

PB 131500. A Study of the Deterioration of Adhesives on Metal Bonds at High Temperatures. By J. M. Black and R. F. Blomquist, for WADC; 45 pages, 8 by 10½ in., paperbound, side-stapled; $1.25 per copy. (Evaluates FPL-878 and FPL-891, phenol-epoxy resin adhesives, for bonding aluminum and stainless steel.)

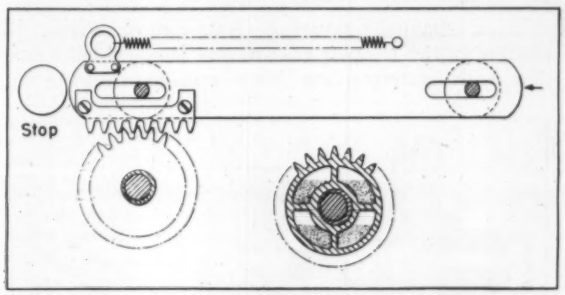
PB 131633. Metallurgical Factors Affecting Tensile Properties of Fe-Al Base Alloys. By W. J. Buehler and C. G. Dairymple, U. S. Naval Ordnance Laboratory; 29 pages, 8 by 10½ in., paperbound, side-stapled; $1.00 per copy. (Previous alloy studies; Thermenol used as base in making several alloys; two melting methods used; evaluation of alloy mechanical properties.)

NOTEWORTHY

Patents

Dynamic Damping Gear

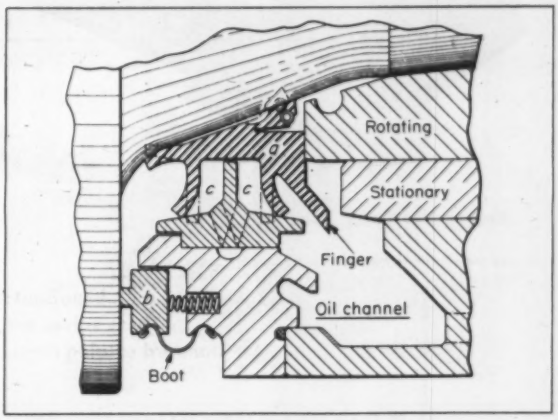
Angular momentum of a damping gear engaged with a heavier assembly cushions the impact of the assembly as it strikes a stop, or carries the assembly to the



stop if the assembly's own momentum has failed to do so. Intentionally excessive backlash between gear and rack teeth make this performance possible. Action of the gear is adjustable in two ways: 1. An eccentric journal which carries the gear can be rotated to change the depth of tooth engagement. 2. Momentum of the gear can be adjusted by the addition or removal of loose shot in gear compartments. *Patent* 2,826,094 *assigned to National Cash Register Co., Dayton, Ohio, by James E. Johnson.*

Heavy-Duty Seal Pair

Two kinds of flexible seals and two kinds of lubricants exclude corrosive fluid and abrasive scale from a heavy-duty bearing assembly. One seal, *a* (labyrinth type), is held against the journal member and rotates with it. The other, *b*, is fixed to a stationary bearing



How TITCHENER eliminated 32 assembly operations!

For years, a cigarette vending machine manufacturer* had been using a match book finger assembly consisting of a machined square rod with 8 spring steel fingers. Mounting each finger required drilling and tapping two holes in the rod and fastening with two screws . . . requiring 48 assembly operations. Titchener's wire/strip engineers designed a wire assembly of 8 formed wire fingers, each spot welded to a round rod. The result? A much lower cost per unit plus a lighter, more durable assembly.

Wire/Strip has much to offer . . . use our complete wire/strip design and manufacturing facilities as a part of your production team. Send us a sketch, drawing or actual part; better yet, bring it with you to our plant. We'll show you what we can do . . . there's no obligation.

*name of manufacturer on request.

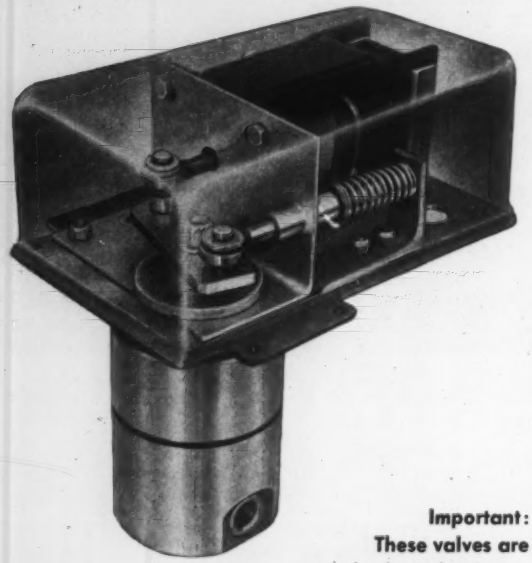
Learn more about WIRE/STRIP design! Send for this **FREE** WIRE/STRIP construction handbook.

E. H. TITCHENER & CO.
65 Clinton St., Binghamton, N. Y.

Send new "DESIGN" handbook on wire/strip construction!

NAME TITLE
COMPANY
STREET
CITY STATE

10,000 P.S.I. SOLENOID VALVES



Important: These valves are standard catalog items.

● They are available for immediate delivery (in stock) at standard valve prices, for a service which generally requires costly (made-to-order) special valves.

● Shut off and 4-way valves in ¼, ⅜ and ½ inch port sizes are rated for 10,000 P.S.I. liquid or gases. They will withstand surges of up to 15,000 P.S.I. without damage to the valves' sealing qualities (designed for a burst pressure of 30,000 P.S.I.).

Solenoids are available for 115, 230 and 460 volt A.C. operation.

● Long maintenance-free service is achieved through the leak-proof "Shear-Seal" design. Optically flat metal to metal sealing surfaces (of the self-aligning sealing rings and the mating rotor face) are protected by staying in constant intimate contact: flow is always through the center of the "Shear-Seals," never across sealing surfaces. Sealing qualities actually improve as the seals lap themselves to a more perfect fit with each valve operation. There is no external shaft leakage because the pressure is confined to the flow passages.

For complete data write for catalog S-10000.

CONTROL VALVE DIVISION

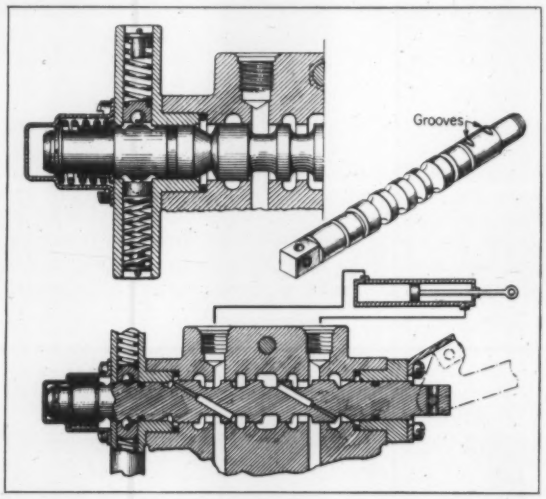
barksdale valves

5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

member. Heavy oil or grease, fed to a chamber *c*, formed by seal *a* and a stationary T-ring, fills and lubricates the labyrinth. Lighter oil, forced from adjacent rotating and stationary bearing members, is collected in a channel for recirculation. A flinger projection on seal *a* guides the collection action. Seal *b*, mainly a fluid barrier, is held in place by an annular boot and loaded against a radial bearing surface by helical springs. *Patent 2,868,574 assigned to Morgan Construction Co., Worcester, Mass., by Charles A. Rich, Jr.*

Directional Flow-Control Valve

In a manually-actuated, fluid-control valve, a plunger carries annular grooves and lands which function with corresponding bores and passageways in



the valve body. By means of a handle, the plunger is moved axially between two limit positions at which fluid flow through the valve is in opposite directions. When the handle is released, fluid pressure on conical lengths of the plunger returns the assembly to a neutral condition. At the convenience of an operator, the valve can be locked open in either limit position by a detent subassembly. The detent can be inactivated by rotating the plunger about its own axis 90 deg. *Patent 2,862,518 assigned to Webster Electric Co., Racine, Wis., by John C. McAlvay.*

Overload-Recording Mechanism

Located between the input and output gears of a power transmission, a mechanical counter indicates the relative gain or loss of angular displacement (in terms of shaft revolutions) when output and input speeds differ, as in the case of overloaded output. Being fixed to the output gear, the counter assembly rotates at the speed of the entire transmission, and does not record, when input and output speeds are the same. When the speeds are not the same, torque differential frees a latch and roller follower from a notched wheel in a master wheel assembly. The same action occurs at

electric motion control facts

for IDEA MEN

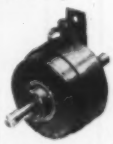
Electromagnetic "scram clutches" guard nuclear reactor

Ingenuity is illustrated in the way Warner SF-400's are used in this vital control rod drive developed by Alco Products, Inc., for the Alco-built Army's packaged power reactor at Fort Belvoir, Va.

In a reactor, control rods operate as a "throttle" to control the rate of reactivity.

This is done by lowering rods of neutron-absorbing material into the reactor to carefully calibrated positions. And that's where Warner electric clutches come in.

Clutches perform dual function in control rod drive requiring reliability



The Warner SF-400 clutches are mounted and controlled so as to provide both freewheeling release for emergency scramming and positive drive during normal rod positioning. Each clutch, consisting of three main parts, is mounted as follows:

1. **The field** is bearing-mounted to the drive shaft and does not move.

2. **The rotor,** which transmits torque from the armature to the drive shaft (Fig. 2), is bushed and rides free on the thru shaft.

3. **The armature** is mounted to the outer member of an overrunning cam-type clutch.

During normal operation, a control rod is positioned by the continuously engaged clutch acting through the outer member of the overrunning clutch. In "scramming," the clutch is de-energized, breaking the electromagnetic couple between drive and control rod shafts. This lets the rod fall by gravity into the reactor. At the same instant, the drive motor starts rotation downward. Any obstruction of the rod causes engagement of the overrunning clutch, transmitting full motor torque from the thru shaft to the control rod drive shaft, breaking the rod free.

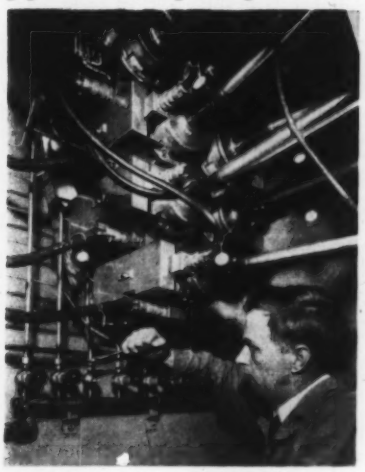


Fig. 1—Seven control rod drives in place on nuclear reactor. Compact Warner clutches are inside welded caps, requiring only lead wires for actuation.

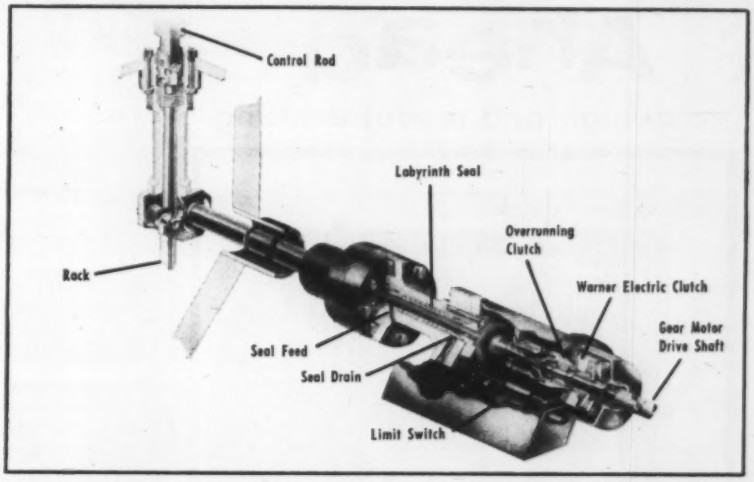


Fig. 2—Cross section of control rod drive now in use on Army nuclear reactor. Warner SF-400 electric clutch provides both freewheeling release for emergency scramming and automatic control during normal rod positioning.

Clutches survive elimination tests

It is easy to understand why reliability was *the* important factor in a drive of this type. The rods have to move fast in response to a scram signal, working under water at temperatures up to 450° F, pressures of 1200 lb psi. The external mechanisms, including the clutches, work in air at temperatures up to 120° F and humidity of 100%. Preliminary evaluation of several drives and actuating methods showed the labyrinth seal drive (above) to be the best suited for the job.

A one-year reliability test by the manufacturer put the Warner electric clutch through 60,000 scram cycles. In other tests, rods were left in a stationary position for periods of up to two months, then scrammed to determine if the operating environment affected reliability. (It didn't.) In addition, the Army gave these drive units a 700-hr acceptance trial under close scrutiny by officials from the Atomic Energy Commission.

A new dimension in machine design

Warner's compact electromagnetic clutches and companion-sized brakes open new doors to design of highly controlled drives for machinery, aircraft and missile accessories, and other automatic equipment. Direct electrical operation gives the designer something to hang his hat on when multiple shafts and power drives must be accurately synchronized, operated in close sequence, cycled, or otherwise controlled automatically. Control hardware doesn't get out of hand. And, there's practically no limit to motion control possibilities using clutches and brakes that:

1. **Release and engage in milliseconds.**
2. **Operate directly from actuating current.**
3. **Permit stepless adjustment of torque and speed.**

WANT MORE IDEAS? Warner will show you factual case histories demonstrating how electric brakes and clutches can be used to solve your problems.

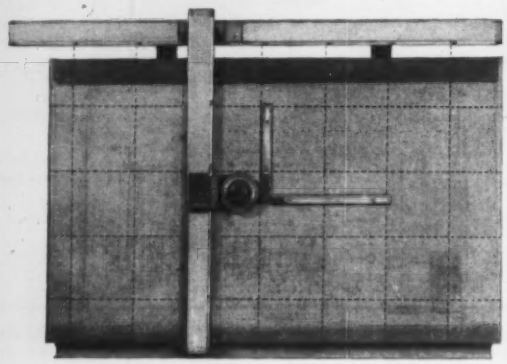
WARNER **ELECTRIC BRAKES AND CLUTCHES**

Warner Electric Brake & Clutch Co.
Beloit, Wisconsin

You get MORE in a Drafting Machine when you specify UNIVERSAL

A Giant Step Ahead

in design and layout drafting

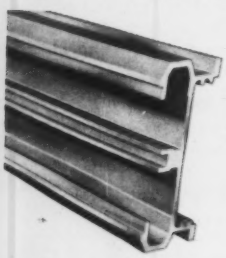


Exclusive 10" Graduations on Both Beams provide, in effect, Dimensional Grid Reference... Invaluable for Long Lines, Accuracy and Reference Point Transfers

The Advanced New Universal

Tracmaster

X-Y Track Drafting Machine



- Safe, accurate balancing at ANY board angle. No adjusting.
- Built better to last longer . . . Exclusive 5 Year Guarantee.
- Exclusive rugged beam rails for permanent, true straight line tracking.

Look to UNIVERSAL

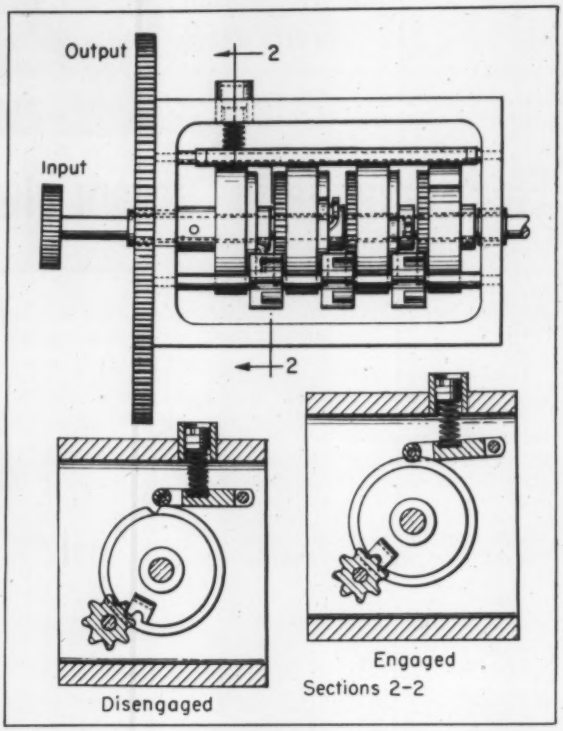
The RIGHT drafting machine for every drafting need

• *UNIVERSAL TRACMASTER** • *UNIVERSAL DESK-TOPPER**
• *UNIVERSAL BOARDMASTER** • *DURALINE** *SCALES*

*TRADEMARK

Write today for complete information

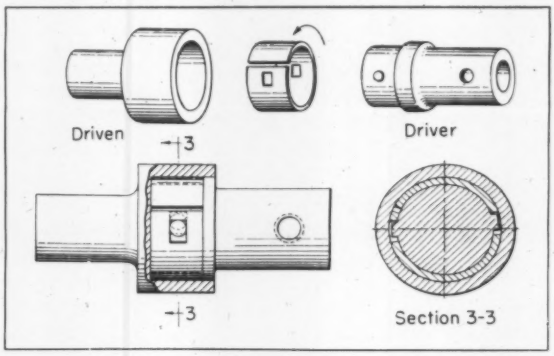
UNIVERSAL DRAFTING MACHINE CORP.
7960-A Lorain Avenue • Cleveland 2, Ohio



three counting wheels because all latches are fixed to a common shaft. The wheels count, to a maximum of 999, until uniform speed is restored. At that time, all latches are aligned and the spring-loaded latch locks the counter assembly. *Patent 2,868,000 assigned to the United States of America (Air Force) by Archie Gold.*

Spring-Band Friction Coupling

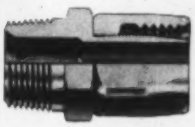
In a three-part friction coupling, a single intermediate member enables torque transmission in either direction of rotation. That member is a split, spring band with



two rectangular slots, each slightly displaced from a diameter through the other. Two pins on the driving member fit into the slots, and the band bears outward in the ID of the driven member. Due to clearances between pins and slots, one pin drives clockwise, and the other drives counterclockwise. The amount of torque

Cut Costs! Use Aeroquip 2601 Lightweight Hose and Fittings for Engine Oil and Fuel Lines

Type 2601 HOSE construction: synthetic rubber inner tube, cotton inner braid, single wire braid reinforcement, impregnated cotton braid cover. Working pressures: 125 psi. to 1000 psi., depending on size. Temperature range —40°F. to +300°F. Sizes ¼" to 2".



Male Pipe—¼" to 2"

S.A.E. Swivel—¼" to ¾"
J.I.C. Swivel—¼" to 2"
P.T.T. Swivel—1" and 1¼"

Split Flange Fittings in straight, 45° and 90° elbows

Swivel Nut Fittings in straight, 45° and 90° elbows plus special configurations

New Aeroquip 2601 Lightweight Hose is a high quality product that offers important advantages to engine and equipment designers:

Special construction features permit savings to the OEM customer of 4¢ to 13¢ per hose/foot over conventional heavy-duty hose lines.

It has a wide operating temperature range to meet the requirements of all engine systems (—40°F. to +300°F.).

It can be used, on Aeroquip approval, for fluid transfer applications such as air, water, mineral oil and hydraulic return lines in addition to engine fuel and high temperature oil lines.

It has good flexing characteristics and outstanding resistance to engine vibration.

It is available in 10 sizes, from ¼" to 2" O.D. tube, with a full range of reusable fittings: S.A.E., J.I.C. and P.T.T. swivel; male pipe; and standard 4-bolt and split flange ends. Standard 45° and 90° elbow fittings plus special elbow configurations are also available.

Full design information is available on Aeroquip 2601 Hose and Reusable Fittings. Fill in and mail the coupon below for a copy of Engineering Bulletin IEB-34. If you have a special fluid line problem, outline your requirements to our sales engineering staff. Write today!

Aeroquip 2601 Hose Lines are now used for diesel fuel and lube oil lines on Clark Equipment Company's Michigan Tractor Dozers.

Aeroquip Corporation,
Jackson, Mich.

Please send IEB-34 on new Aeroquip 2601 Hose and Reusable Fittings.

MD-2

Name _____

Title _____

Company _____

Address _____

City _____ Zone _____ State _____

Aeroquip

REG. TRADEMARK

AEROQUIP CORPORATION, JACKSON, MICHIGAN

INDUSTRIAL DIVISION, VAN WERT, OHIO • WESTERN DIVISION, BURBANK, CALIFORNIA
AEROQUIP (CANADA) LTD., TORONTO 19, ONTARIO

AEROQUIP PRODUCTS ARE FULLY PROTECTED BY PATENTS IN U.S.A. AND ABROAD

Circle 593 on Page 19

WHERE COMPRESSED AIR MUST BE *Oil-Free*...

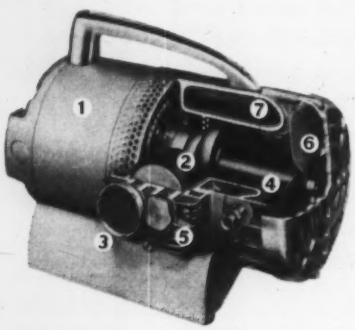
This coffee vending machine is motivated by compressed air supplied by a B&G Compressor. Obviously in an application of this kind, the air must be absolutely oil-free.

The lightweight, compact B&G Air Compressor doesn't need lubrication of any kind—eliminates an oil separator—ends expensive lubrication maintenance. The carbon-graphite piston rings and skirt operate for years without destroying the finish of the cylinder walls.

B&G Oil-less Compressors are available in a complete line of portable, tank-mounted and tankless models.

FEATURES

1. Heavy duty, protected integral motors
2. Carbon-graphite piston rings and skirts
3. Dry valve construction
4. Safety valve
5. Bi-metal cylinder head
6. Blast cooled
7. Combined aftercooler, pulsation chamber, moisture separator



Send for Catalog GO-1156.

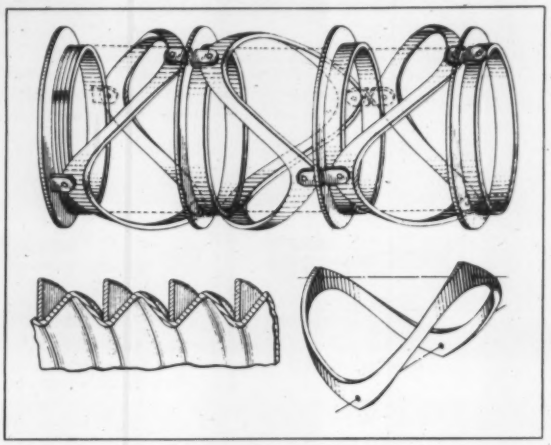
Oil-less
AIR COMPRESSORS
BELL & GOSSETT COMPANY
Dept. FP-67, Morton Grove, Illinois

Circle 594 on Page 19

depends on the arc length of spring between the driving pin and the split. When these distances are unequal, torque in opposite directions is correspondingly unequal. *Patent* 2,868,001 *assigned to Eaton Manufacturing Co., Cleveland, by Robert C. Russell.*

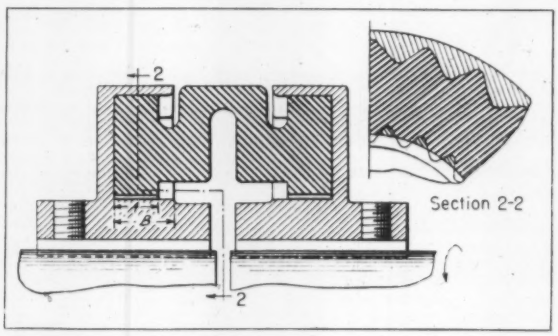
Reinforced Flexible-Tubing Assembly

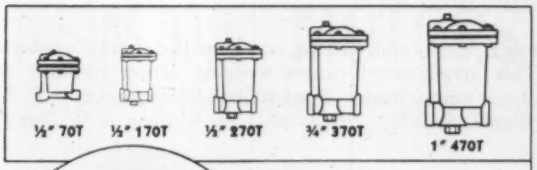
Flexible tubing enclosed by a cylindrical linkage forms tubing which retains its internal volume despite flexing action and pressure differences inside and outside its wall. The tubing can retain atmospheric pressure in a vacuum environment. Bellows-like in section, the tubing is made of relatively nonstretchable rubberized fabric and is fastened at regular intervals to the surrounding linkage. Interconnected gimbal rings enable the linkage to flex, but with no change of interior volume, or pressure, because the figure formed is toroidal. *Patent* 2,865,403 *assigned to Litton Industries, Beverly Hills, Calif., by Allan D. Le Vantine.*



Toothed, Flexible Coupling

On an annular, flexible shaft coupling, intended for heavy-duty service, both outside and inside circumferences are formed in the shape of teeth accommodated by rigid, shaft-end flanges. The tooth forms in the flanges, *B*, are substantially longer than the length of the teeth in the coupling, *A*, to counter disengagement by wrapping action. High-points of tooth con-





Type A UNITRAP

Fast Warm Up Big Capacity

This bucket type steam trap, with its patented Dual-Value, permits one trap to handle all pressures up to 250 lbs. without adjusting or changing of orifices, valves, or weights of buckets. Large orifices and the trigger action of the Dual-Valve assure fast warm up and tremendous capacity. Self-sealing and self-cleaning stainless steel valves and valve seats reduce wear and cut steam losses. UNITRAPS are available in many styles and capacities, with pipe sizes from ½" through 2". Write for Bulletin 800 or contact our nearest office.

*Trade Name–Patented

"WHERE *Good Connections* COUNT"

PERFECTING SERVICE COMPANY, 332 Atando Ave., Charlotte, N.C.

Baltimore—Buffalo—Camden, N. J.—Chicago—Cleveland—Los Angeles
New York—Providence—Hamilton, Ont.—Montreal—Toronto

Circle 595 on Page 19

PAT. PENDING

Saves hours in piping installations

Eliminates leaks in oil, air, water, vacuum, chemical lines

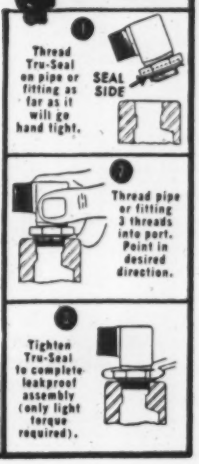
Tru-Seal saves hours in assembling piping installations because it enables you to run your pipe lines in any direction you wish, quickly and easily—without having to recut and re-thread piping sections. Wherever used on air, oil, water, steam, vacuum or chemical lines, it seals perfectly at —100° F. to plus 500° F.—*without the use of pipe dope.* Its installation requires only light tightening torque, thus eliminating over-tightening damage to valves, pumps, compressors, and other fittings.

For further information write

TRU-SEAL DIVISION
FLICK-REEDY CORPORATION

2006 N. Hawthorne Melrose Park, Ill.

"Miller Fluid Power" is also a Div. of Flick-Reedy Corp.


1
Thread Tru-Seal on pipe or fitting as far as it will go hand tight.
SEAL SIDE
2
Thread pipe or fitting 3 threads into port. Point in desired direction.
3
Tighten Tru-Seal to complete leakproof assembly (only light torque required).

Circle 596 on Page 19

NEED A QUIET MOTOR?

If your product will sell better by keeping quiet, we'll help you make it whisper. Hard-to-hear Jack & Heintz *Customized* motors are making silence golden on door operators . . . on meat slicers . . . on floor polishers, and the like.

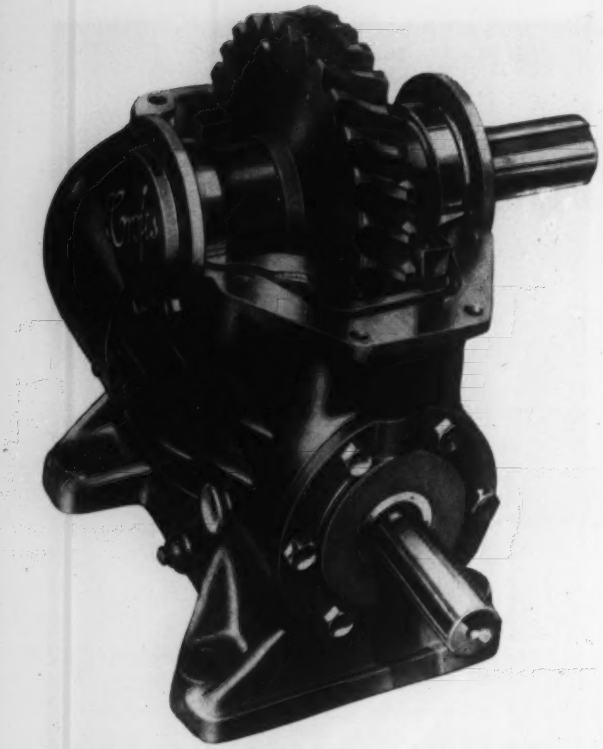
We'll customize beyond mere quiet. Give you special torque, high or low L/D ratio, special contour or finishes. Submersibility is possible in water, oil, gasoline or other fluids. Or, if you foresee high temperature operation, J&H will customize to meet it.

So don't let a limited standard motor compromise what you want to do. It's not worth the sacrifice in product performance and salability.

Call Jack & Heintz for a motor that fits your design perfectly. Our range is ⅓ to 3 hp, up to 15 hp for submersibles.

JACK & HEINTZ, Inc.
COMMERCIAL MOTOR DIVISION
17626 Broadway • Cleveland 1, Ohio

Circle 597 on Page 19



CROFTS 'RADIATION' WORM GEAR REDUCERS

FAN COOLED

CROFTS fan-cooled worm gear reducers are designed to provide *maximum* power outputs in *minimum* case dimensions.

Ordinarily, this would mean trouble from overheating.

But not with CROFTS 'Radiation.'

Temperature rise is effectively controlled by a fan fitted to the worm shaft. This directs a steady stream of cool air along exterior ribs on the gear case surrounding the worm. Vertical ribs on the upper half of the case, plus the large surface area, dissipate remaining heat and maintain maximum operating efficiency.

Here are a few other points about 'Radiation' you'll appreciate:

- CASING . . . constructed of Crofts Semi-Steel, a super quality, close-grained metal of good surface finish and fine machining qualities. Machined oil-tight and dustproof.
- WORM . . . is of Crofts Special "Wormsteel," integral with its shaft. Hardened, ground, polished and finished to fine limits.
- WORM WHEEL . . . of "Croftspun" Special phosphor bronze, centrifugally cast; rim shrunk and pegged to a semi-steel center. Teeth hobbed to fine limits.
- BEARINGS . . . High quality dual purpose ball bearings for both wheel and shafts adequately provide for radial and thrust loads.
- LUBRICATION . . . is provided by a positive lubricating system directing a continuous flow of oil over meshed surfaces of worm and wheel, and also to the bearings.

From .01 to 44 h.p.; ratios from 5-1 to 60-1 at input speeds from 100 to 1,800 r.p.m.

AVAILABLE FROM STOCK

For full descriptive catalog, write:

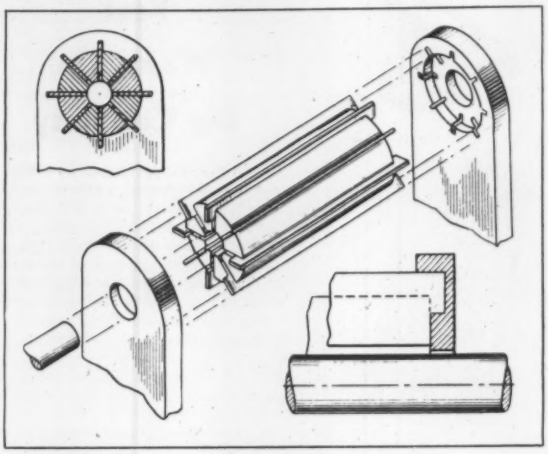
CROFTS U.S.A. INC

POWER TRANSMISSION ENGINEERS

2542 West Peterson Avenue Chicago 45, Illinois

tours, inside and outside, occur on the same diameters. This arrangement causes wedging action resistant to shock torque loads. *Patent 2,867,103 assigned to T. B. Wood's Sons Co., Philadephia, by William A. Williams.*

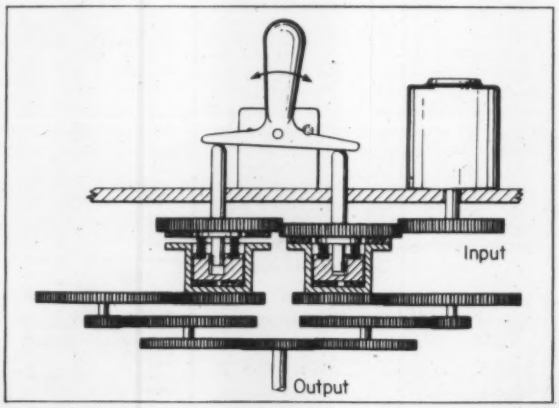
Finned, Carbon Bearing



Designed for use at very high speeds and temperatures where petroleum lubricants are impractical, a carbon bearing employs metal heat-dissipating fins to extend operating life. Carbon wedges are spaced by the fins which carry off a portion of the heat generated. Slots and recesses in the bearing end supports assure that the wedges, but not the fins, contact the rotating shaft. Simplicity of construction simplifies bearing replacement in whole or in part. *Patent 2,866,669 assigned to Fairchild Engine and Airplane Corp., Bay Shore, N. Y., by Joseph S. Brennan.*

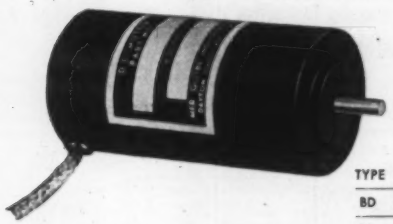
Antibacklash, Reversible, Gear Drive

At the output of a gear drive, reversal of torque is achieved without abrupt disturbances caused by backlash. Two identical trains are permanently engaged to each other, to an output gear, and to a motor gear which drives the trains continuously in opposite directions. Operation of a hand lever reverses output torque. The lever moves input gears axially, but not



NEW D.C. MOTORS

precision / high torque



TYPE	O.D.	LENGTH
BD	1½"	2⅜"
BL	1½"	2 15/16"

Here are two new Globe precision PM d.c. motors which offer unusually high output for package size. In nominal ratings to 1/30 hp., a complete range of standard windings are available, plus special windings as necessary, allowing the designer a wide choice of performance characteristics. Type BD and BA motors are designed to meet MIL-M-8609 and MIL-E-5272 for performance and environment requirements.

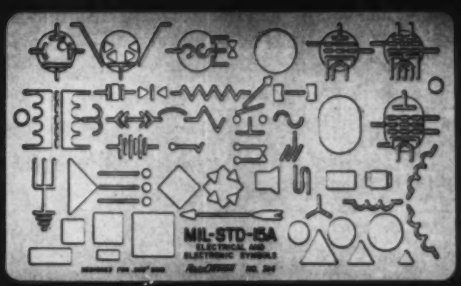
Typical output with a 26 v. winding is 4 oz. in. at 10,000 rpm. Speed governors may be made a part of the package for constant speed in the range of 5,000 to 12,000 rpm. Planetary gear reducers may be incorporated, offering over 100 standard ratios, as well as special ratios. Maximum weight is 11¼ oz. Special modifications welcomed. Fast prototypes. Request Bulletin 112.

GLOBE

Globe Industries, Inc.
1784 Stanley Avenue, Dayton 4, Ohio
Telephone BAldwin 2-3741

Circle 599 on Page 19

MIL STD 15-A TEMPLATE



NO. 314 — 7" x 4" — .200 GRID
NO. 315 — 8¾" x 5" — .250 GRID

$4.00 AT YOUR LOCAL DEALER

Two of the more than 100 Rapidesign Templates—all of which are better made and more useful and lesser priced.

CATALOGUE NO. 60 AVAILABLE UPON REQUEST

RAPIDESIGN INC.

P. O. BOX 429, BURBANK, CALIFORNIA

Circle 601 on Page 19

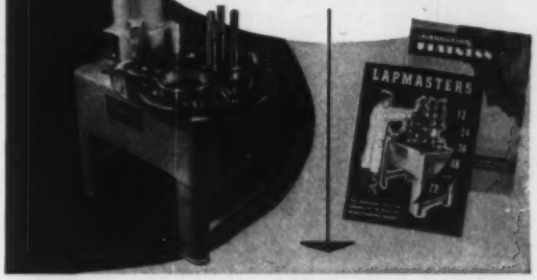
For Precison Flatness and Finish...

on Metals, Ceramics, Quartz and Plastics...

USE A CRANE LAPMASTER

With a Lapmaster you can lap different parts in one cycle—lap a wide range of parts of different materials in short or moderate production—lap identical parts at tremendous production rates and maintain flatness to one light band (.0000116"); surface finish to 2 or 3 RMS. *Production lapping may be the solution to your problem. Get all the facts.*

Full facts on Lapmaster production lapping—Flatness interpretations available in two illustrated booklets. They are yours for the asking.



CRANE PACKING COMPANY

6425 Oakton St., Morton Grove, Ill. • In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

Circle 600 on Page 19

When the design calls for an indicating gauge, specify the best-
MARSH
New catalog covers gauges for every need
MARSH INSTRUMENT CO.
Sales Affiliate of Jas. P. Marsh Corporation
Dept. S, Skokie, Ill.
Marsh Instrument & Valve Co. (Canada) Ltd.
8407 103rd Street, Edmonton, Alberta
Export Dept.,
3501 Howard Street, Skokie, Ill.

Circle 602 on Page 19

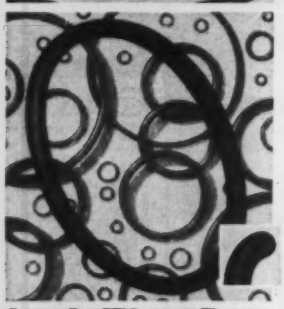
3 GOOD REASONS WHY YOU SHOULD

Go Goshen

for NEW standards of precision and performance

TETRASEALS

. . . rectangular-section rings that give high performance, low-cost sealing for most static and some moving applications. Interchangeable with standard o-rings . . . need no special tooling. A Goshen exclusive.



O-RINGS

. . . precision molded from wide range of compounds, to meet today's ever-toughening conditions. Available in a complete range of AN, MS, SAE and JIC standard sizes, plus non-standard sizes and special shapes.

CUSTOM-MADE PARTS

. . . such as bellows, bushings, diaphragms, gaskets, grommets and others, are precision-fabricated to meet strictest requirements, as to compound, service life and operating satisfaction. These parts are not stocked, but produced promptly on order.

Whenever you have a seal or rubber part problem, Go Goshen for the solution.

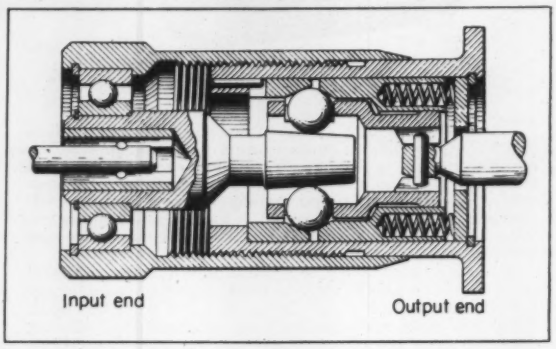
Send for Literature

☐ TETRASEALS ☐ GORLUBE (Low Friction Treatment)
☐ O-RINGS ☐ GROMMETS

Goshen Rubber Co., INC.
1729 S. TENTH ST., GOSHEN, INDIANA

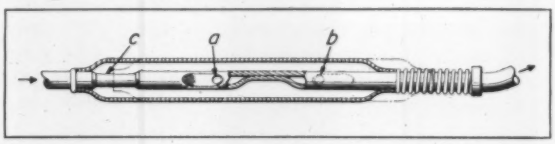
far enough to disengage them. The same action engages a clutch in one train and simultaneously disengages an identical clutch in the other. Each clutch has a small drag when disengaged. *Patent* 2,868,028 *assigned to Bendix Aviation Corp., Teterboro, N. J., by John C. Ziegler.*

Adjustable, Planetary-Ball Transmission

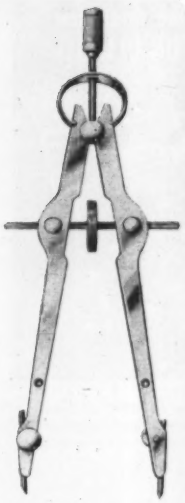


Balls, of the type in antifriction bearings, function as planetary gears in an adjustable, torque transmission assembly. The unit is capable of an infinite number of speed ratios between definite high and low limits. The balls are positioned by a conical, axial driving race, a fixed outer race tapered in section, and a movable outer race, spring-loaded and tapered in section. Precise values and interrelations of the angles on all three races prevent slipping of the balls. As the balls circulate, they carry with them the ball cage which is fixed to the output shaft. Speed ratios are changed by turning a female-threaded and graduated outer shell. This action causes axial translation of the inner race. In turn, the balls move radially and find a new pattern of contacts on all three races. *Patent* 2,868,038 *assigned to Liquid Controls Corp., North Chicago, Ill., by Henry Robert Billeter.*

Air Filter, Cleanable in Place



An air filter assembly is quickly cleaned without removal from the air line, and without removal of any of its parts. About midway through the filter, an axial tube is crimped shut to cause inlet air to enter the interior of a sleeve through hole *a*. In the sleeve, the air assumes a tortuous path at reduced speed before passing out through hole *b*. These conditions in the sleeve enable foreign matter to settle there. To remove accumulated sediment, the sleeve is drawn back against the force of a spring until a reduced section *c* is exposed. Through this opening, gravity or an air jet removes the dirt. *Patent* 2,868,323 *assigned to General Motors Corp. by Roger M. Young.*



A quality

Stainless STEEL COMPASS

offered at a new low price

Precise construction and unexcelled performance have made the VEMCO stainless steel Blue Dot line of instruments famous. The price now makes it an incomparable value. American made VEMCO drawing instruments are produced by modern manufacturing processes, which permit the use of durable steels not found in hand-made instruments.

See your VEMCO dealer

SC 110 COMPASS
$4.95
LIST PRICE

Write for complete instrument catalog

V. & E. MANUFACTURING CO.
DEPT. ST-2 P. O. BOX 950-M
PASADENA, CALIFORNIA

VEMCO

Circle 604 on Page 19

BHEW

Hydraulic Cylinders

- Basic Designs
- Superior Quality
- Specific Adaptations
- Application Engineering

THIS IS BHEW'S 1500 PSI SERIES DOUBLE-ACTING GENERAL-PURPOSE CYLINDER, designed around standard components, but custom-built to suit *your* application. Available in a variety of mountings, with or without adjustable or non-adjustable rod ends.

• Self-adjusting "V" packed rod glands • "U" cup seal on pistons • Honed steel barrel • High-tensile, hard chrome plated rods • Packings for extreme high and low temperatures most non-inflammable fluids.

Production parts save you money, do the job better! BHEW basic cylinders can easily be modified to fit your *specific* product applications. You benefit from production economies; you get custom-built cylinders.

Let's discuss your design and application problems —

FREE!
Write today for Hydraulic Cylinder Engineering Reference Data — 78 dimensional basic designs for general — and special-purpose double-acting cylinders. SAVE TIME.

BENTON HARBOR ENGINEERING WORKS, INC.
622 Langley Avenue St. Joseph, Michigan

BH EW

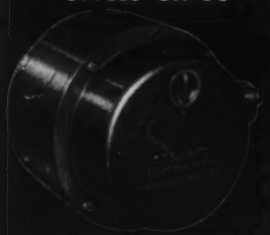
Circle 606 on Page 19

Stearns electro-magnetic explosion-proof DISC BRAKES

for hazardous locations

(Underwriters Laboratories Approved Class II, groups E*, F*, G*)

STYLES UH-50 — UH-70 — EXG-70



NEW Max. Torque Ranges — 1½ to 75 lb ft — 17 Sizes

Rugged, Cast Construction

Field-Proved Reliability

Floor, or NEMA "C" Motor Flange Mountings

Exclusive "Visi-Indicator"

E — dusts, including aluminum, magnesium, and their alloys
F — atmospheres containing carbon black, coal, or coke dust
G — atmospheres containing flour, starch, and grain dust

Request Bulletins 2902 F, 3002 F, 3602 F

Stearns ELECTRIC CORPORATION
120 NORTH BROADWAY
MILWAUKEE 2, WISCONSIN

Circle 605 on Page 19

IN PERFORMANCE

No. 1

IN DURABILITY

IN ECONOMY

BENDIX ELECTRIC FUEL PUMP FOR EVERY INDUSTRIAL USE

In every type of industrial application, the Bendix* Electric Fuel Pump has proved itself with outstanding performance under extremely adverse conditions. In tests conducted under U. S. military supervision, it has proved itself at temperatures ranging from 114° to −76° Fahrenheit. It's easy to install and service, has a built-in pressure release, pumps more gallons per hour and positively prevents vapor lock. It will outperform any other fuel pump anywhere near its price. Write for descriptive folder and specifications. *REG. U.S. PAT. OFF.

Bendix-Elmira, N.Y.
ECLIPSE MACHINE DIVISION

Bendix
AVIATION CORPORATION

Circle 607 on Page 19

Send for FREE SAMPLE PACKET of the three new
MUELLER "70 SERIES" ALLIGATOR CLIPS
Low-cost, streamlined clips
with SNAP!

which is taking 1/2500th second to snap shut upon a wafer. Talk about acceleration!—the upper jaw hits 60 MPH in three-eighths of an inch. The upper jaw and flying wafer fragments have been caught in many images along their paths of movement.

Photographed by means of a special process, it graphically illustrates the "snap" in Mueller's traditionally snappy springs. These springs provide a mean, corrosion-cutting bite for perfect test connections.

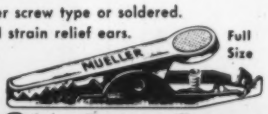
THE NEW "70 SERIES" ALLIGATORS FEATURE:

Simple, direct, streamlined design, and lower cost than the famous "60 Series".

Faster, easier connection, whether screw type or soldered.

A new patented hinge, and cord strain relief ears.

WRITE FACTORY TODAY FOR FREE SAMPLE PACKET SHOWN ABOVE



Full Size

Mueller Electric Co
1589Q East 31st Street • Cleveland 14, Ohio

Circle 608 on Page 19

For HIGHEST ELECTRICAL & MECHANICAL Efficiency!
New
JONES 2400 SERIES PLUGS & SOCKETS

Improved Socket Contacts. Four individual flexing surfaces. Positive contact over practically their entire length.

Both Plug and Socket Contacts mounted in recessed pockets greatly increasing leakage distance, INCREASING VOLTAGE RATING. Plug and Socket Contacts cadmium plated. Add to appearance of your equipment. Interchangeable with Jones 400 Series.

Ask for Catalog 22, Complete line Jones Plugs, Sockets, Terminal Strips.

P-2406-CCT
Plug—with cable clamp in top.

S-2406-SB
Socket with shallow bracket for flush mounting.

Jones
HOWARD B. JONES DIVISION
CINCH MANUFACTURING CORPORATION
CHICAGO 24, ILLINOIS
SUBSIDIARY OF UNITED CARR FASTENER CORP.

Circle 609 on Page 19

WHAT'S YOUR PROBLEM?

PARTS? MATERIALS? COMPONENTS? FINISHES?

Perhaps one of our advertisers in this issue of MACHINE DESIGN has the solution to your dilemma. We'll be willing to bet that this issue contains information that is essential to answering your problem.

Fill out one of the yellow inquiry cards and send it to us. No letter or postage is necessary. We will forward your inquiry to the advertiser and he will reply directly to you.

Why not do it right now?

USE THE YELLOW CARD ON PAGE 19.

Advertising Index

AC Electronics Division, The, General Motors Corporation 273
Aeroquip Corporation 263
Air Marine Motors, Inc. 232
Ajax Flexible Coupling Co., Inc. 227
Allen-Bradley Co. 97, 98
Allen Manufacturing Co. 177
American Brake Shoe Co., Denison Engineering Division 249
American Screw Co. 178
American Sealants Co. 238
American Smelting and Refining Co., Federated Metals Division 67
American-Standard, Detroit Controls Division .. 86
American Steel & Wire Division, United States Steel Corporation 128, 129
American Stock Gear Division, Perfection Gear Co. 217
Ampco Metal, Inc. 31
AMP, Inc. 258
Apex Machine & Tool Co., The 37
Armstrong Cork Co., Industrial Division 95
Arwood Precision Casting Corporation 44
Atlas Precision Products Co., Division of Prudential Industries, Inc. 208

Babcock & Wilcox Co., The, Tubular Products Division 5
Barksdale Valves, Control Valve Division .. 260
Bearings Company of America, Division of Federal-Mogul-Bower Bearings, Inc. 53
Bell & Gossett Co. 264
Bellows Co., The 207
Bendix Aviation Corporation, Eclipse Machine Division 270
Bendix-Westinghouse Automotive Air Brake Co. 109
Benton Harbor Engineering Works, Inc. 269
Bethlehem Steel Co. 200
Bodine Electric Co. 1
Bound Brook Oil-less Bearing Co. ..... Inside Front Cover
Bower Roller Bearing Division, Federal-Mogul-Bower Bearings, Inc. 215
Burndy Corporation, Omaton Division 65

Cambridge Wire Cloth Co., The 225
Cannon Electric Co. 231
Carpenter Steel Co., The 72
Carter Controls, Inc. 36
Castings Engineers, Inc. 228
Century Electric Co. 110, 111
Chace, W. M., Co. 205
Chain Belt Co. 189, 191, 193, 195, 197, 199
Chicago Rawhide Manufacturing Co. 2
Chikson Co. 46, 47
Chrysler Corporation, Amplex Division 106
Cinch Manufacturing Corporation, Howard B. Jones Division 270
Cincinnati Gear Co. 176
Clare, C. P., & Co. 257
Columbia-Geneva Steel Division, United States Steel Corporation 128, 129
Commercial Shearing & Stamping Co. 114
Connecticut Hard Rubber Co. 255
Consolidated Electrodynamics, Electro Mechanical Instrument Division 74
Copperweld Steel Co., Aristoloy Steel Division 11
Cramer Controls Corporation 56
Crane Packing Co. 267
Crofts U.S.A., Inc. 266
Curtis Universal Joint Co., Inc. 234
Cutler-Hammer, Inc. 130

De Laval Steam Turbine Co. 91
Delron Co., Inc., The 244
Denison Engineering Division, American Brake Shoe Co. 249
Detroit Controls Division, American-Standard 86
Dodge Manufacturing Corporation 116, 117
Dormeyer Industries 253
Drop Forging Association 70
Du Pont, E. I., de Nemours & Co., Inc. 52
Durametallic Corporation 180
Dynamatic Division, Eaton Manufacturing Co. 175

Eastman Mfg. Co. 123
Eaton Manufacturing Co., Dynamatic Division 175
Eclipse Machine Division, Bendix Aviation Corporation 270
Elastic Stop Nut Corporation of America 241
Electric Specialty Co. 221
Enjay Co., Inc. 125

Fafnir Bearing Co., The 173
Fairbanks, Morse & Co. 94
Fawick Corporation, Fawick Airflex Division .. 102
Federal-Mogul-Bower Bearings, Inc., Bearings Company of America Division 53
Federal-Mogul-Bower Bearings, Inc., Bower Roller Bearing Division 215
Federated Metals Division, American Smelting and Refining Co. 67
Fenwal, Inc. 48
Firestone Tire and Rubber Co., The, World Bestos Division 226
Flick-Reedy Corporation, Miller Fluid Power Division 113
Flick-Reedy Corporation, Tru-Seal Division 265
Foote Bros. Gear and Machine Corporation .. 218
Formica Corporation 104, 105
Formsprag Co. 84, 85
Franklin Electric Co., Inc. 103
Frantz, S. G., Co., Inc. 224

Gamble Brothers, Inc. 80
Gardner-Denver Co. 212
Gast Manufacturing Corporation 214
Gear Specialties, Inc. 16
General American Transportation Corporation, Parker-Kalon Division 124
General Electric Co. 38, 39, 118, 119, 170, 243
General Electric Co., Metallurgical Products Department 243
General Motors Corporation, The AC Electronics Division 273
General Motors Corporation, Hyatt Bearings Division 57, 58, 59, 60
General Plate Division, Metals & Controls Corporation 194
Gleason Works 9
Globe Industries, Inc. 267
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 77
Goshen Rubber Co., Inc. 268
Grip Nut Co. 254

Hassall, John, Inc. 238
Heinze Electric Co. 180
Heli-Coil Corporation 248
Hi-Lo Manufacturing Co. 206
Hitchener Manufacturing Co., Inc. 236
Hobbs, John W., Corporation, A Division of Stewart-Warner Corporation 236
Hoke, Inc. 41
Hoover Ball and Bearing Co. 73
Houdaille Industries, Inc., Wales Strippit Co. Division 240
Howard Industries, Inc. 100, 101
Huck Manufacturing Co. 202
Hunt Valve Co. 274
Hyatt Bearings Division, General Motors Corporation 57, 58, 59, 60
Hydro-Line Manufacturing Co. 223

Imperial Brass Mfg. Co., The 233
Industrial Tectonics, Inc. 32
International Nickel Co., Inc., The 99
International Packings Corporation 245

Jack & Heintz, Inc., Commercial Motor Division 265
James, D. O., Gear Manufacturing Co. 224
Jeffrey Manufacturing Co., The 120
Jenkins Bros. 75
Jones, Howard B., Division, Cinch Manufacturing Corporation 270
Joy Manufacturing Co. 108

MACHINE DESIGN

Penton Building, Cleveland 13, Ohio
Main 1-8260

BUSINESS STAFF

ROBERT L. HARTFORD
Business Manager

MARY L. CALLAHAN
Advertising Service Manager

RICHARD A. TEMPLETON
Research and Circulation Manager

ROBERT E. LESSING
Production Manager

District Offices

New York 17 .....60 East 42nd St.
RUSSELL H. SMITH, JAMES A. STANGARONE
Murray Hill 2-2581

Simsbury, Conn. .....17 Deerfield Lane
ALAN C. BUGBEE
Oldfield 8-4764

Rochester 10 .....33 Landing Rd. S.
EDWARD F. CLANCY
Greenfield 3-1223

Dresher (Philadelphia), Pa. ....1335 Harris Rd.
CHANDLER C. HENLEY
Mitchell 6-2585

Cleveland 13 .....Penton Bldg.
JACK W. WALTON, DON J. BILLINGS
Main 1-8260

Detroit 35 .....15800 West McNichols Rd.
CHARLES F. REINER
Broadway 3-8150

Chicago 11 .....520 North Michigan Ave.
HOWARD H. DREYER, ROBERT Z. CHEW
DONALD A. IVINS
Whitehall 4-1234

Los Angeles 36 .....5943 West Colgate Ave.
F. J. FULLER
Webster 1-6865

San Francisco 4 .....57 Post St.
Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....1106 Pine Valley Rd.
FRED J. ALLEN
Griffin 7854

Clearwater, Fla. .....1954 Jeffords Dr.
H. G. ROWLAND
(Clearwater) 39-9493

Dallas 35 .....818 Exchange Bank Bldg.
JAMES H. CASH
Fleetwood 1-4523

London, S.W.1 .....2 Caxton St., Westminster

Published by

THE PENTON PUBLISHING COMPANY

G. O. HAYS .....Chairman
R. C. JAENKE .....President
F. G. STEINEBACH ....Vice President and Secy.
F. O. RICE .....Vice President
J. P. LIPKA..Treasurer and Assistant Secretary

Also Publisher of
STEEL, FOUNDRY, NEW EQUIPMENT DIGEST, AUTOMATION

MACHINE DESIGN is sent at no cost to management, design and engineering personnel whose work involves design engineering of machines, appliances, electrical and mechanical equipment, in U. S. and Canadian companies employing 20 or more people. Copies are sent on the basis of one for each group of four or five readers. Consulting and industrial engineering firms, research institutions and U. S. government installations, performing design engineering of products are also eligible.

Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday and copyrighted 1959 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NEP

TIPS AND TECHNIQUES

VOLUME II ENGINEERING AIDS

- **Simplifying Constructions**
- **Utilizing the Slide Rule**
- **Construction Aids**
- **Shortcuts for the Engineer**

Helpful Tips and Techniques that apply to engineering methods, are now available in this one-volume reference. This manual contains 32 pages of illustrated time-and-money saving procedures that every engineer can use.

$1.00 a copy

Order from

MACHINE DESIGN

Reader Service
Penton Building
Cleveland 13, Ohio

(Remittance or Company Purchase Order must be enclosed with order)

Advertising Index

Kaiser Aluminum & Chemical Sales, Inc. ..78, 79
Kaydon Engineering Corporation, The 21
Kennametal, Inc. 256
Keuffel & Esser Co. 81
Kohler Co. 107

Landis & Gyr, Inc. 222
Lewellen Manufacturing Co. 15
Link-Belt Co. 45
Logansport Machine Co., Inc. 83
Lovejoy Flexible Coupling Co. 206

McGill Manufacturing Co., Inc., Bearing Division 211

Madison-Kipp Corporation 112
Manhattan Rubber Division, Raybestos-Manhattan, Inc. 68, 69
Marsh Instrument Co. 267
Meehanite Metal Corporation 178, 179
Metallurgical Products Department of General Electric Co. 243
Metals & Controls Corporation, General Plate Division 194
Metals & Controls Corporation, Spencer Division 247
Micro Switch Division, Minneapolis-Honeywell Regulator Co. 29
Midland-Ross Corporation, Owosso Division .. 252
Milford Rivet & Machine Co., The 228
Miller Fluid Power Division of Flick-Reedy Corporation 113
Miniature Precision Bearings, Inc. 181
Minneapolis-Honeywell Regulator Co., Micro Switch Division 29
Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division .. 235
Monarch Aluminum Mfg. Co. 206
Mueller Electric Co. 270

National Acme Co., The 229
National Lock Washer Co., The 222
National Supply Co., The 230
National Tube Division, United States Steel Corporation 128, 129
Nichols, W. H., Co. 234

Ohmite Manufacturing Co. 88, 89
Onan, D. W., & Sons, Inc. 43
Orange Roller Bearing Co., Inc. 187
Owosso Division, Midland-Ross Corporation .. 252

Packing Division, Raybestos-Manhattan, Inc. 68, 69
Parker-Kalon Division, General American Transportation Corporation 124
Parker Rust Proof Co. 219
Peerless Electric Co., The, Electric Motor Division 216
Penn Metal Co., Inc. 76
Perfection Gear Co., American Stock Gear Division 217
Perfecting Service Co. 265
Philadelphia Gear Corporation 96
Pittsburgh Steel Co. 54, 55
Plastics Products Division, Raybestos-Manhattan, Inc. 68, 69
Protective Closures Co., Inc., Caplugs Division 121
Prudential Industries, Inc., Atlas Precision Products Co. Division 208
Purolator Products, Inc. 90

RapiDesign Inc. 267
Raybestos-Manhattan, Inc. 68, 69
Recordak Corporation 61
Reliance Electric and Engineering Co. ..... Inside Back Cover
Republic Steel Corporation 92, 93
Robbins & Myers, Inc. 115
Rollway Bearing Co. 64

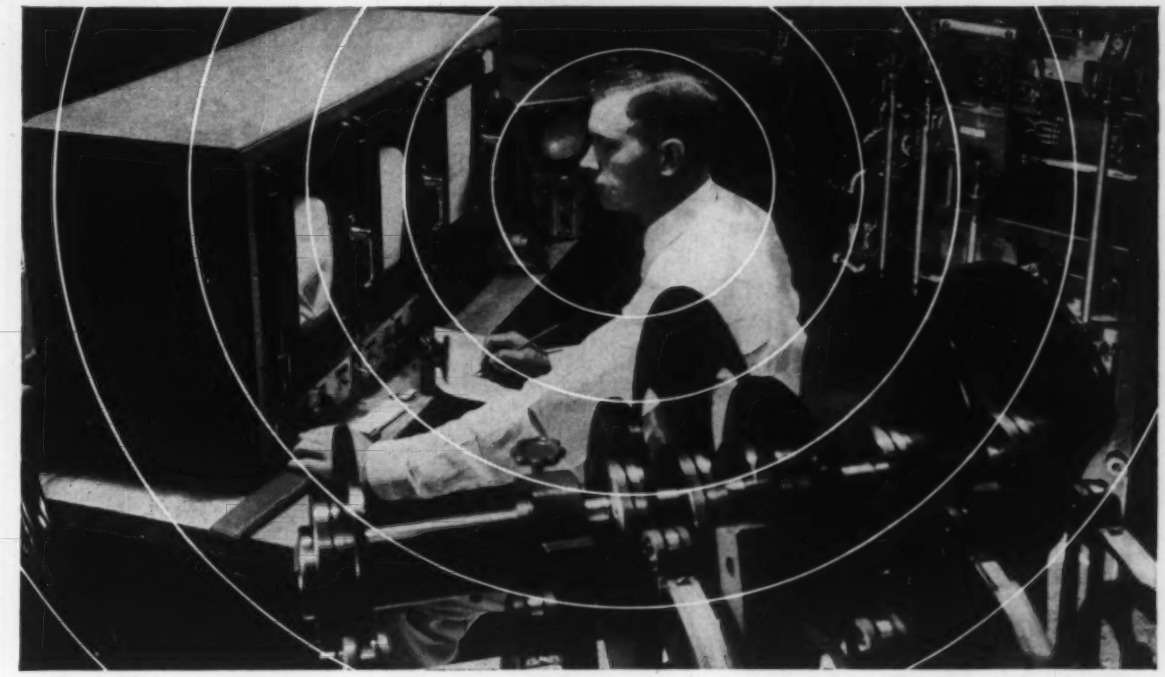
Sandusky Foundry & Machine Co. 87
Schrader's, A., Son, Division of Scovill Mfg. Co., Inc. 203
Scovill Mfg. Co., Inc., A. Schrader's Son Division 203
Sealmaster Bearings Division, Stephens-Adamson Mfg. Co. 49
Shenango Furnace Co., The, Centrifugally Cast Products Division 183
Sier-Bath Gear and Pump Co., Inc. 71
Sigma Instruments, Inc. 201
Simmons Fastener Corporation 196
SKF Industries, Inc. 220
Skinner Electric Valve Division 184
Snap-Tite, Inc. 182
Spencer Division, Metals & Controls Corporation 247
Sperry Rand Corporation, Vickers, Inc. Division 209
Staedtler, J. S., Inc. 239
Standard Pressed Steel Co., Flexloc Locknut Division 82
Standard Screw Co. 7
Stearns Electric Corporation 269
Stephens-Adamson Mfg. Co., Sealmaster Bearings Division 49
Stewart-Warner Corporation, John W. Hobbs Division 236
Stow Manufacturing Co. 242
Stratoflex, Inc. 42
Superior Tube Co. 251

Taylor Fibre Co. 40
Tennessee Coal & Iron Division, United States Steel Corporation 128, 129
Thomson, Judson L., Mfg., Co. 237
Timken Roller Bearing Co., The ..... Back Cover
Tinnerman Products, Inc. 198
Titchener, E. H., & Co. 259
Torrington Co., The 13
Torrington Co., The, Specialties Division 185
Townsend Co. 246
Tru-Seal Division, Flick-Reedy Corporation .. 265
Tubular Rivet & Stud Co. 210
Tuthill Pump Co. 122

United Aircraft Products, Inc., United Metallic "O" Ring Corporation 254
United Metallic "O" Ring Corporation, Division of United Aircraft Products, Inc. 254
United States Gasket, Plastics Division of Garlock 188
United States Graphite Co., The, Division of The Wickes Corporation 62, 63
United States Steel Corporation, Subsidiaries 128, 129
United States Steel Export Co. 128, 129
United States Steel Supply Division, United States Steel Corporation 128, 129
Universal Drafting Machine Corporation 262

Valley Electric Corporation 210
V. & E. Manufacturing Co. 269
Veeder-Root, Inc. 190
Vickers, Inc., Division of Sperry Rand Corporation 209
Victor Mfg. & Gasket Co. 66
Virginia Gear & Machine Corporation 96

Waldron, John, Corporation 204
Wales Strippit Co., Houdaille Industries Division 240
Warner Electric Brake & Clutch Co. 261
Waterman Engineering Co. 27
Webster Electric, Oil Hydraulics Division 192
Western Gear Corporation 33
Westinghouse Electric Corporation, Standard Control Division 50, 51
Westinghouse Electric Corporation 50, 51, 126, 127
Whitney Chain Co. 213
Wickes Corporation, The, The United States Graphite Co. Division 62, 63
Wiegand, Edwin L., Co. 34, 35
Wittek Manufacturing Co. 250
World Bestos Division of The Firestone Tire and Rubber Co. 226



How far can an engineer go at AC?

You can use and develop all your talents in AC's bustling instrumentation business.

You can put the finest equipment to work for you . . . on interesting and varied projects . . . at AC's world-wide facilities. What's more, you can enhance your professional status by working on advanced degrees in engineering schools located near AC plants.

All this plus the comfort of long range security. For today AC turns out the AChiever inertial guidance system and many other electro-mechanical, optical and infra-red devices. Tomorrow you'll help AC produce instrumentation devices for the "space age."

If you are a physicist, mathematician, or graduate engineer in the electronics, electrical or mechanical fields—*you can go places at AC, because AC is going places.*

Talk to the people at AC about it soon. Just write the Director of Scientific and Professional Employment: Mr. Robert Allen, Oak Creek Plant, Box 746, South Milwaukee, Wisconsin; or Mr. M. Levett, Dept. C, 1300 N. Dort Highway, Flint 2, Michigan.

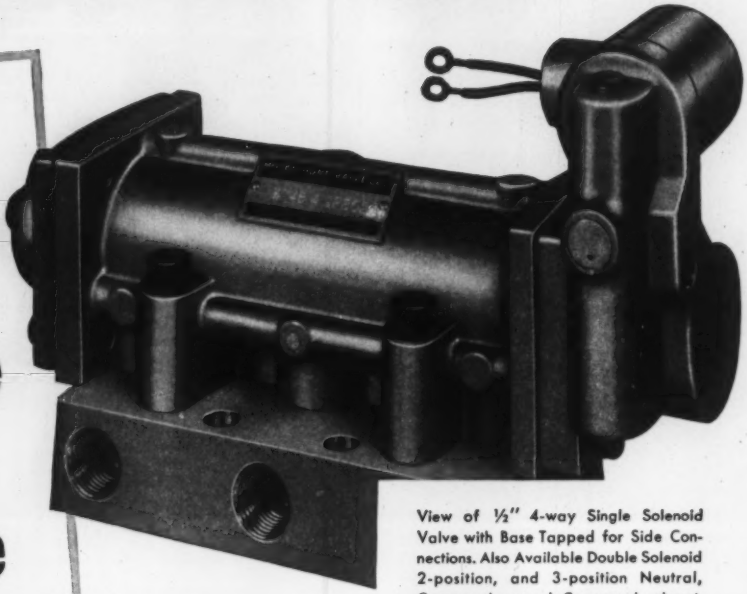
Inertial Guidance Systems • Afterburner Fuel Controls • Bombing Navigational Computers • Gun-Bomb-Rocket Sights • Gyro-Accelerometers • Gyroscopes Speed Sensitive Switches • Speed Sensors • Torquemeters • Vibacall • Skyphone

AC SPARK PLUG ❀ THE ELECTRONICS DIVISION OF GENERAL MOTORS

HUNT

sets the pace again...

with a
FULL FLOW
½" Valve
at a
½" Price



View of ½" 4-way Single Solenoid Valve with Base Tapped for Side Connections. Also Available Double Solenoid 2-position, and 3-position Neutral, Compound-on and Compound-exhaust.

. . . in a completely comprehensive range of valve actions

THE UNIVERSAL SIZE. We asked O.E.M. buyers, large and small users; men out in the plant and plant managers,—"If you had to standardize on just one size of control valve, what size would you select?" Almost without exception they replied;—"½" size, it meets 85% or more of our requirements".

UNTIL NOW buyers have had to choose between a ⅜" valve tapped ½" but with **only ⅜" flow** (about 167 CFM); or, a ¾" valve tapped ½" but **selling at the ⅜" price.**

AGAIN HUNT LEADS. Now, from Hunt, you can get a **full flow ½" valve** (257 CFM at 100 psig) in a complete range of actions, 2-way, 3-way, 4-way and 5-way, including single and double solenoid in AC or DC, any voltage, any cycle, explosion proof solenoid if desired; also hand lever, double pilot, pilot operated automatic return, and mechanically operated both directions, or with automatic return.

GET FULL DETAILS NOW about these new Hunt Valves that give you the flow you need, in the action you want, **at a ½" rather than ¾" price.**

More startling HUNT designs to come!

Send for Bulletin No. 582-A TODAY!

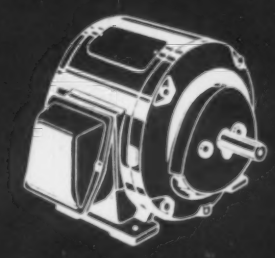
HUNT

40 *Quick-As-Wink*® AIR AND HYDRAULIC CONTROL **Valves**

Manufactured by HUNT VALVE COMPANY, 2013 East Pershing St., Salem Ohio

Circle 610 on Page 19

so quiet you can hear a pin drop



Reliance brings a permanent hush to fan motors. These Reliance Motors are quiet because they're sleeve bearing motors. The silence is permanent because of a new method of lubrication, Permawick.

Permawick is an oil packed, fiberous substance that is more stable than grease, but more fluid than felt.

Oil saturated Permawick is extruded into a large reservoir surrounding the sleeve bearing. Lubrication lasts for months with no dripping or oozing. Infrequent lubrication requires only a few drops of oil.

Put this Reliance Silent A-c. Motor to work today, available 3/4 thru 15 hp. For more information contact your local Reliance Representative or write for Bulletin No. B-2512.

Product of The Reliance Electric and Engineering Company, manufacturers of a-c. motors, Master Gearmotors, Reeves Drives, V*S Drives, Super "T" D-c. Motors, generators, controls and engineered drive systems.

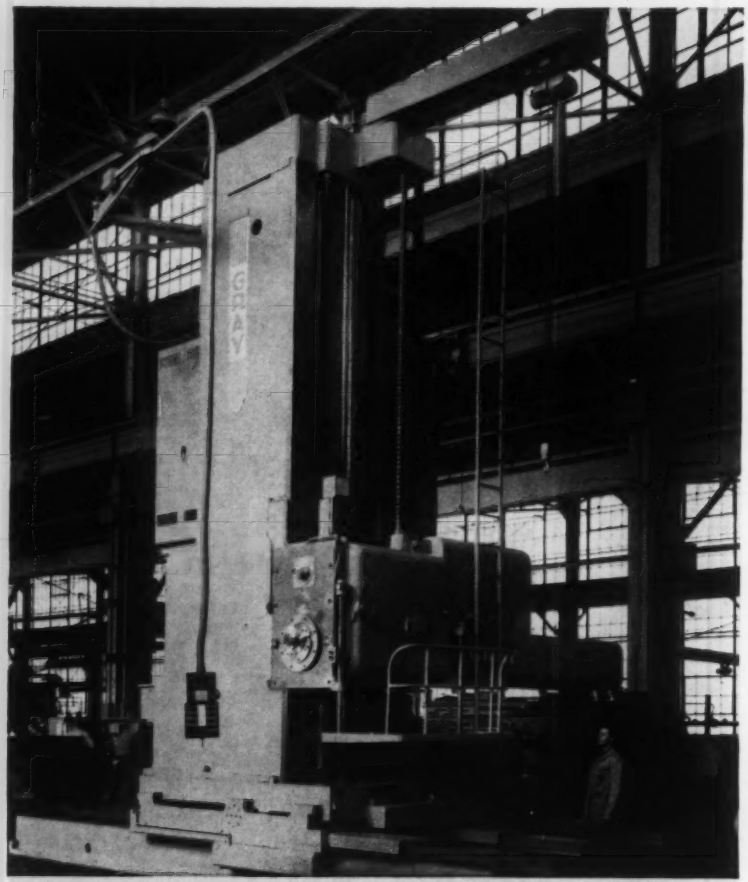
RELIANCE ELECTRIC AND ENGINEERING CO.

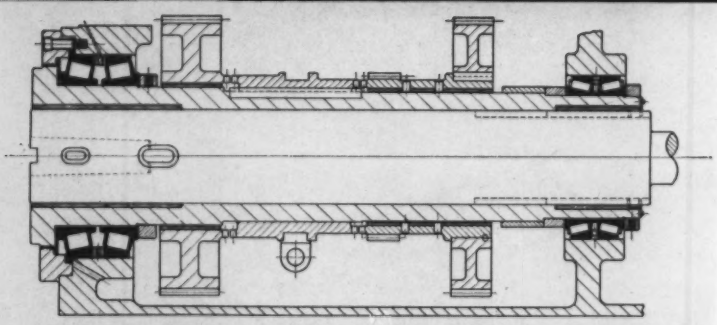
DEPT. 282A, CLEVELAND 17, OHIO
CANADIAN DIVISION: TORONTO, ONTARIO
Sales Offices and Distributors in Principal Cities

MASTER R REEVES

Circle 402 on Page 19

"We switched to TIMKEN® bearings to get greater accuracy and capacity," reports The G. A. Gray Company





How **THE G. A. GRAY COMPANY** mounts the spindle of its new Model 880-FC boring machine on Timken tapered roller bearings to get spindle accuracy, assure precision performance.

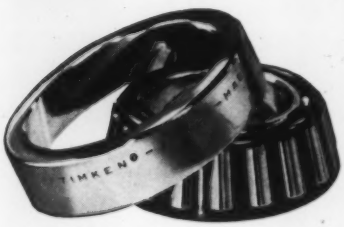
HERE'S a precision giant! It's The G. A. Gray Company's new 212½-ton Model 880-FC horizontal boring, drilling and milling machine. Weighing 425,000 lbs., it stands 27 ft. high, spans 76½ ft. in length. It can machine a block of metal 65 ft. long and 15½ ft. high—works with a precision of .00025". Yet one man operates the huge tool. To keep the spindle running accurately, Gray engineers switched to Timken® tapered roller bearings.

Spindle held rigid. Timken bearings hold the spindle in positive alignment. Their tapered design lets them take both radial and thrust loads in all combinations. And full-line contact between rollers and races gives Timken bearings extra load-carrying capacity.

Heavy shocks no problem. Rollers and races of Timken bearings are case-carburized to have hard, wear-resistant surfaces and tough, shock-resistant cores.

Friction virtually eliminated. Timken bearings are geometrically designed and precision-made to roll true. They roll the load. They practically eliminate friction, run smoother, longer with minimum maintenance. For extra quality-control, we even make our own steel. No other American bearing maker does. And you can get Timken tapered roller bearings with maximum runout of 75 millionths of an inch. For all these advantages, specify bearings trademarked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO". Makers of Tapered Roller Bearings, Fine Alloy Steels and Removable Rock Bits.

This symbol on a product means its bearings are the best.



BETTER-ness rolls on **TIMKEN®** tapered roller bearings

Circle 403 on Page 19